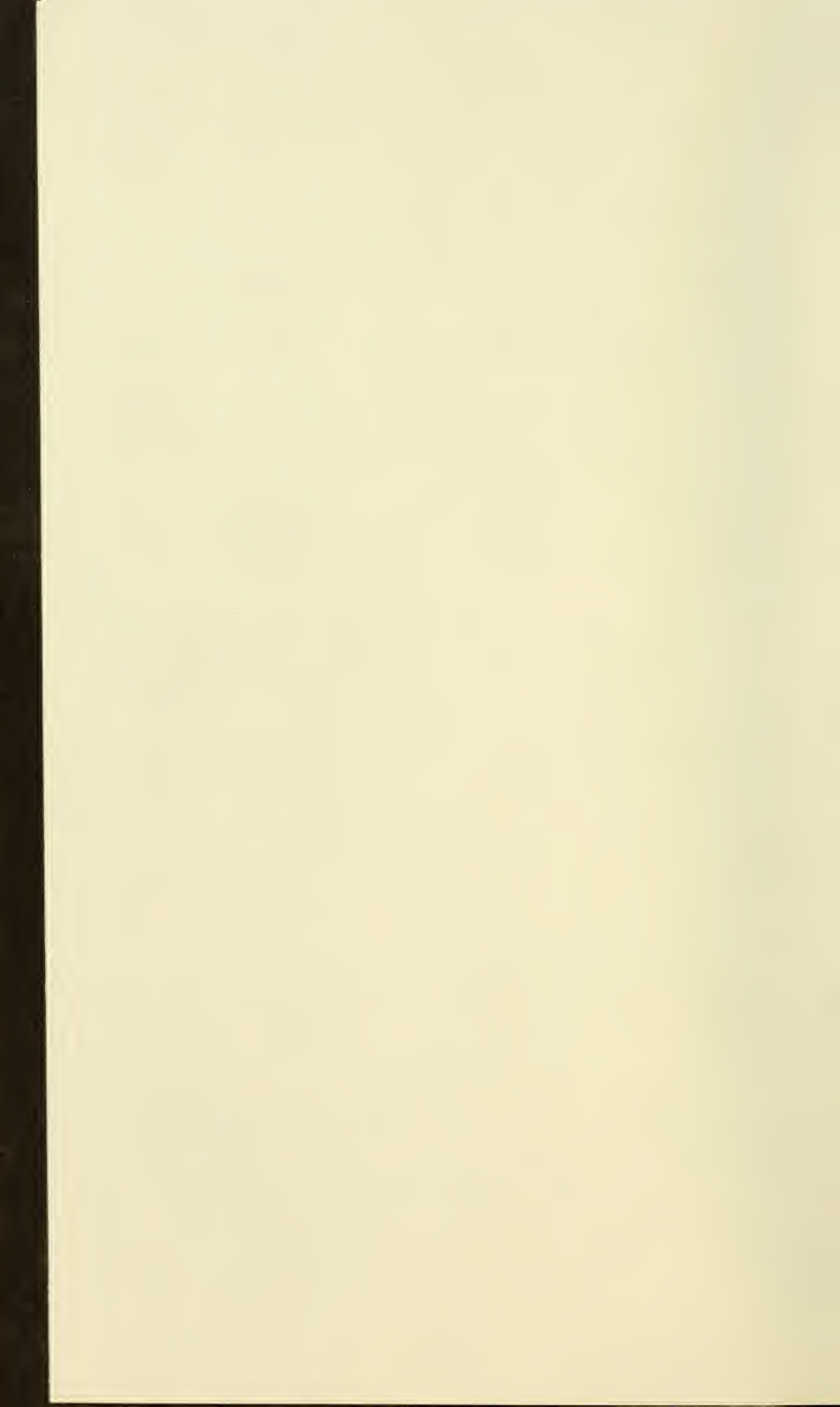












Dynamic Skiametry

in

Theory and Practice

Embracing Its Association with Static Skiametry and
with Those Optometric Methods Wherein the
Correlation of Accommodation and
Convergence Must Be
Considered

BY

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To
MY COLLEAGUE,
CHARLES F. PRENTICE, M E.,

ONE OF THE FIRST TO RECOGNIZE THE SCIENTIFIC VALUE OF DYNAMIC
SKIOMETRY, AND WITH WHOM I HAVE BEEN ASSOCIATED IN OPTO-
METRIC ORGANIZATION AND EDUCATION WORK SINCE 1895, THIS LITTLE
VOLUME IS AFFECTIONATELY DEDICATED.

PREFACE

The progress made in optometry during the past decade has perhaps been influenced by no one division more than it has by that of *Dynamic Skiametry*, for the revolutionary character of this new objective method has of necessity developed many minor factors which were unknown when the former book, "*A System of Ocular Skiametry*," was issued.

For this reason it is now deemed wise to present new explanations of the theory and practice of *dynamic* shadow testing and, at the same time, retain all of the old that has been found good.

Static skiametry, or that method known by the blanket term "*retinoscopy*," has been explained so often by other writers that it is thought quite unnecessary to add to the length of this little volume further than by a brief description of the cardinal points involved, hence it will be taken for granted that the reader is more or less familiar with the optical principles underlying Bowman's great discovery, and with the added improvements made by Cuignet and others prior to 1902, when the *dynamic method* was originated and made public by the author.

NEW YORK,
October, 1911.

PREFACE TO SECOND EDITION

From one viewpoint it might be deemed unfortunate that success in the practice of *dynamic skiametry* calls for the high class skill it does in order to correctly read the shadow's action, but from another angle this may be a means of separating the competent from the incompetent, for only through conscientious and painstaking effort can adeptness in this work be achieved.

No startling developments have taken place in either the theory or the practice of *dynamic skiametry* since the publication of the previous edition of this book. The author, however, has changed his views somewhat regarding the correctness of classifying the difference between the findings by the *static* method and those by the *dynamic* as being entirely composed of *latent* errors, for he now has reason to believe that the visual organs in their effort to meet individual requirements adjust *accommodation* and *convergence* in a manner to give the *fusion sense* the greatest possible aid. Thus *exophoria* might cause some *hyperopia* to still remain *latent*, or it might explain why *presbyopia* is often less than that indicated by the Donder's table.

As harmony between *accommodation* and *convergence* is an essential, it logically follows that the method which objectively determines the exact amount of refractive assistance required to produce this harmony must be of infinitely greater value than those methods where an estimate of the *dynamic* condition is necessarily based upon the uncertainty of *static* findings.

Dynamic skiametry is perhaps not all it will be some day, but as at present understood it gives a most valuable datum to the examiner, and one that is *unobtainable by any other known, dependable means*. It is therefore very gratifying to note the increasing numbers of those who are now recognizing this merit.

NEW YORK, JANUARY, 1915.

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Dynamic Skiametry
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CHAPTER I.

OCULAR SKIOMETRY AS A SYSTEM.—ITS VALUE IN OPTOMETRY AND THE OPTICAL KNOWLEDGE NECESSARY TO MASTER IT, INCLUDING DIFFICULTIES TO BE OVERCOME.

SKIOMETRY AS A SYSTEM. Formerly there was only one method employed in measuring eyes by the so-called *shadow test*, and this one method was made to do service for the six-year-old child and the sixty-year-old adult.

This one method was also employed for measuring the *myope* of high degree and the *hypermetrope* of low. Long standing habits of suppression of *accommodation* or *convergence*, due to impaired co-ordination, were entirely ignored and *presbyopia* was never a factor to be considered. Indeed, all eyes, like all Chinamen, were said to "look alike."

It is not many years since eminent authorities claimed that the recognition and correction, with lenses, of *hyperopic* errors of less than one diopter was equivalent to taking an unfair advantage of a patient, and therefore savored of charlatanism. What is now known as *eye strain* was classified as *latent hypermetropia* and of trifling importance unless of high degree.

But the foreword in optometry, particularly during the past few years, has been to pay more attention to minor details for, as in other walks, both service and comfort are often secured by giving heed to the little things. This care and attention has developed the fact that greater accuracy in shadow testing can only be obtained by applying methods which take into consideration the patient's age, and other previously overlooked factors requiring varying procedure in varying cases.

The word "*system*" is defined as "a series of methods," so

it is easy to understand why *ocular skiametry* or, literally, eye-shadow-measuring, came to be known as a *system of ocular skiametry*.

VALUE OF SKIAMETRY. In the general practice of his profession the most difficult problem that confronts the optometrist is the fitting of his patient's preconceived notions as to the kind of glasses needed, and the manner in which they are to be worn, so in attempting to make plain the true value of *static* and *dynamic* skiametry the problem which confronts the writer is the overcoming of the previously formed opinion that most readers have, for many inquirers into the merits of shadow testing seem to be possessed with the belief that *every* case which presents itself is capable of being both easily and accurately refracted by means of Bowman's great discovery. This expectation being as inconsistent with the real facts as it would be to expect like results from trial case tests or by any other *one* optometric method.

The truth can perhaps be fairly expressed by saying that shadow testing bears to trial case testing much the same relation that the addition of a column of figures from the top bears to its addition from the bottom.

Skiametry will uncover at a single sitting optical conditions which it would be quite impossible for ordinary trial case tests to do. On the other hand, the latter will show visual conditions of which the former can tell nothing. Viewed again from a similar position we find that the two general methods for estimating ocular errors of refraction, known by the terms *objective* and *subjective*, are like seeing for one's self and taking the testimony of others. Usually either method is fairly reliable in ordinary cases, but in extraordinary ones—the kind that make and break reputations—the evidence can be none too corroborative.

So we find skiametric and trial case testing to be inter-dependent, both systems having their weak and strong points, and

one aiding in the judgment requisite for the successful application of the other, skiametry coming first because it is the great refractive pilot, or pathfinder, and because, too, there are many conditions, other than errors of refraction, that are shown up by its use and which, if it were not for this early use, might needlessly prolong an otherwise short examination.

It is hoped, therefore, that this point is made clear regarding the value of shadow testing. It is deemed of no more nor less value than the trial case test, and that neither one is infallible, and that both are absolutely essential in all prime cases, whether the results obtained by either coincide with those of the other or not, for this very lack of coincidence is often the key which enables a trained judgment to solve a refractive riddle.

By basing their judgment upon the principle that the proof of the pudding lies in interviewing the one who has chewed the string, some credulous inquirers have been led to estimate the merits of shadow testing by taking the testimony of those who have falsely pretended to possess a thorough knowledge of it, and this unreliable information has led them to believe that if skiametry is faulty in some hands it must be faulty in all. Whereas the reverse reasoning would in all probability be productive of better results, for that which one can achieve by study and practice it is quite possible for others to achieve by equal application and effort, and sometimes by even less where assistance is given by skilled instructors.

For nearly four decades the ablest optometric researchers have striven their utmost to find a better *objective* means than skiametry for determining the optical condition of eyes, but so far without avail. And judging from the present advanced knowledge regarding optics and optometry it is pretty safe to say that the shadow test is here to stay, for a long time at least, and that those whose duty it is to adapt glasses to the eyes of others will find their work more reliable and much easier if they will take

the time to thoroughly master this valuable means for ascertaining ocular refractive conditions in a manner independent of the patient's intelligence.

Now this phrase, "independent of the patient's intelligence," may prove somewhat misleading, since even those who are experienced in skiametric work find many cases in which the results obtained are very unsatisfactory indeed. Yet, when an examiner measures a case by skiametry and notes an error of refraction which later on is confirmed by the trial case test, he feels that he has received advance information of a truly "independent" character, and upon which he can rely with greater confidence than if this information had been denied him. On the other hand, if the trial case test does not confirm the mirror findings, then the mirror is employed again to confirm the trial-case findings. The *subjective* is used to check the *objective*, and then the *objective* again to corroborate the *subjective*.

OPTICAL KNOWLEDGE NECESSARY. Expressed in a broad way, the optical knowledge necessary to achieve skiametric success is *all* the optical knowledge a student can obtain. But keeping in mind the practical side of the work there will be found a few essentials which are clearly indicated before intelligent progress can be reasonably expected.

The general optical principles of the shadow test in its simplest form are not very complicated. Taken, however, in connection with its optometric associates skiametry represents, as a whole, a rather high order of knowledge regarding both physical and physiologic optics. It also requires in its application a certain amount of skill or dexterity in the manipulation of indispensable mechanical devices, such as the skiascope and skiameter, no matter whether the latter be a simple trial frame with test lenses, or a more elaborate and useful apparatus.

There are two leading accomplishments in shadow testing in which an examiner must be proficient before he can achieve

success. The first of these is the control of the reflected light and the determination of the direction of the shadow's motion, under both favorable and unfavorable conditions. The second lies in being able to add and subtract known refractive lens quantities and to tell with precision what their ray-bending value is at all distances from an eye under examination. To express it tersely then, an examiner must be able to detect *any* action of the shadow and to know exactly what the optical value of this action is when influenced by either lenses or fixation.

The first of the above requirements can be gained by daily practice, but the second requires considerable study and application, as it involves a knowledge of angles of light, or ray values, as well as of refraction, or lens values.

When a patient's eye is considered as an *object*, instead of as a *subject*, then its refractive condition must be determined by noting the behavior of the light reflected from the retina as it leaves the eye, and methods of procedure known as *objective* must therefore be applied.

Many students of optics who have confined their efforts to a mastery of *subjective* optometry alone often find themselves quite at sea when they undertake *objective* methods. And the reason for this usually lies in the fact that they have given attention to the subject of light as it travels in but one direction, namely, as it *enters* an eye.

One of the foundation principles taught in optical text-books is that light returns over the same course which it has traveled, hence if parallel rays of light are made to pass through a convex lens they will come to a focus at the so-called "strength" of the lens. Invert this order, by placing a lighted candle at the focus of the lens, and the rays of light will diverge until they pass through the lens, after which they will be parallel. See Figs. 1 and 2.

In shadow testing the retina of an eye is the apparent source of light, although in reality the retina is only a poor quality of

mirror which reflects the light thrown into the eye by the skiascope. This illumination, or reflection, behaves like a piece of red flannel, or any other visible object which acts as a high or low grade mirror according to its ability to reflect light. Glass with amalgam backing, and polished metals being of the highest order, while lampblack and black velvet are of the lowest.

FIG. 1.

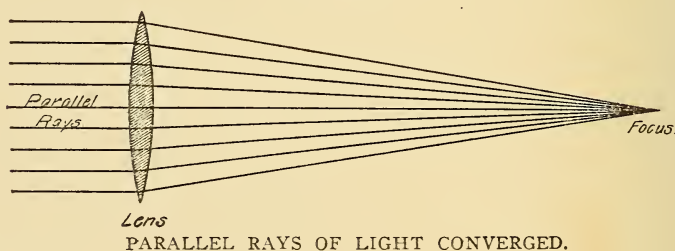
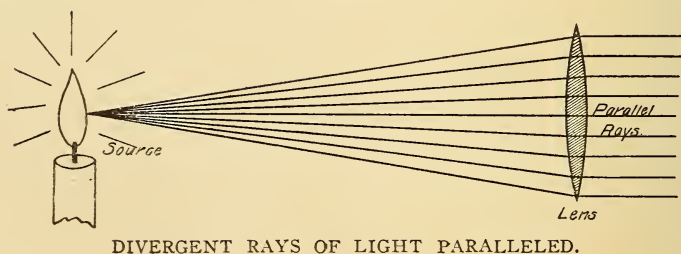


FIG. 2.



The correlation of *accommodation* and *convergence* is another subject which students of ocular skiametry must understand in order to do their work intelligently. Thus it will be seen that skiametric proficiency involves a pretty thorough grounding in something more than rudimentary optics. With the elimination of the use of the concave mirror, however, and

by the aid of modern apparatus it is now possible to dispense with many details which formerly resulted in the confusion of beginners. Still, notwithstanding this, a student will find much that will call forth his best efforts before he can feel assured of the reliability of his findings.

It is one thing to master ocular skiametry under *regular* conditions and quite another to rightly differentiate the *irregular* and apply that judgment which secures success. But, as in other studies, the deeper the student delves the more he finds to learn, and the easier do the foundation principles become. The wise searcher after optical facts, which in the aggregate constitute optical knowledge, will first learn the A, B, C of light and lenses, together with the reduction and transposition of the latter, and next he will master physiologic optics, in addition to the art of subjectively correcting with lenses any manifest conditions which may be met. The student may then be said to possess sufficient optical knowledge to begin the study of ocular skiametry with a fair chance of achieving success.

DIFFICULTIES TO OVERCOME. The stumbling blocks in ocular skiametry are not few, and they seem to grow apace as the system becomes perfected in its many details. The first great obstacle which usually presents itself is place, or examination room. The medical refractionist who takes up this work may already be provided with a regulation dark-room for his ophthalmoscopic work, and in this room he attempts to practice successful skiametry. The conditions being poor, he gets poor results and abandons the work in the belief that shadow testing is sadly overrated.

The non-medical refractionist may possibly go to the other extreme. The specious plea that a dark room is unnecessary is listened to, then not being able to use a *cycloplegic*, and having a knowledge of the *static* method only, he wonders why his skiametric work varies so with his trial case findings. And

then, too, because he possesses a sufficient degree of skill to feel comparatively sure of the action of the shadow in an occasional case, he either blames the system or virtually condemns it by faint praise.

Next to a poorly-arranged examination room in point of discouragement with shadow-testing comes an inadequate source of illumination. Almost any lamp, whether electric, gas or oil, looks to a novice as though it ought to prove of sufficient intensity to determine a shadow's action, because when the light is reflected into a naked eye the fundus reflex seems fairly bright, but by placing a lens or two in front of this eye, or by permitting the patient to look in an unfavorable direction, such a pronounced diminution will often be produced, in the definition of the shadow, as to render accurate work impossible.

Even where the source of illumination is fifty-candle power, or more, the experienced examiner will meet with cases where the deeply pigmented retina gives back so poor a reflection that only the greatest care and skill can determine the action of the shadow.

There is a vast difference in general illuminating power between a flame that is hooded so as to show only a small aperture and one that is not, for a dark-room light to be satisfactory must not be too large. Its apparent intensity should resemble the "glory-hole" of a furnace, and then if this should prove too bright for an occasional supersensitive eye it can always be diminished by moving the patient farther away from it.

The law that light decreases in proportion to the square of the distance at which it is used, enables a light intensity equal to sixty-candle power at two feet away to be decreased to fifteen-candle power by withdrawing to a distance of four feet. Thus it will be seen that with a powerful source of illumination an examiner can readily reduce it to almost any candle power he desires.

Just how high a candle power the human eye can bear without doing it injury varies, undoubtedly, with individuals and the duration of the exposure. A hundred-candle power lamp hooded so that only a limited portion of its general radiant energy is available could probably be comfortably borne by the average eye under ordinary skiametric conditions for several minutes, whereas the length of time for a proper measurement is only a matter of seconds. Too bright a light therefore need not be feared when the patient does not look directly at the reflection in the mirror.

In using a bright light, however, there is one thing an examiner should always remember, as it can properly be classified among the stumbling blocks to be avoided, and that is to never allow himself to look directly at the source of his illumination prior to or during an examination. The reason is that the sensitiveness of his own retina is such as to retain the impressions made by a bright light to such a degree that duller objects cannot be clearly seen for several minutes thereafter, and, as a consequence, if an examiner permits himself to look directly at his lamp for an instant or two and then tries to use his mirror he will find it very difficult to detect the dull outline of the shadow, or note its action. If an inspection of a lamp is necessary to determine its condition, or distance away, it is a wise examiner who will derive his information by looking a few inches to one side of the flame and not directly at it.

Another stumbling block in the road to skiametric success lies in corroded, soiled and dusty mirrors, especially at the edge of the so-called "peep-hole" of the skiascope. Every examiner should possess at least two or more of these instruments, so when one gets out of order it can be sent to the factory for re-silvering. Mirrors, to give the best service, must not be of too great a diameter, nor must their peep-holes be large or bored through the glass. Consequently these peep-holes, which are really not holes in the strict sense of the word, but round spots

of clear glass, made by scraping off the silver of the mirror, must be kept immaculately clean so as to prevent particles of dust from interfering with the free passage of light, or else the shadow's action will be perceptibly dimmed.

One of the underlying causes of the success achieved in many branches of modern science is undoubtedly due to ultra-cleanliness and attention to details, and so it will be with advanced optometry as regards details, for dealings with imaginary quantities of elastic ether, as light is termed, call for extreme care on the part of the examiner, if he is of the kind that will be satisfied with nothing short of the highest attainment.

A thorough knowledge of lenses is still another important factor, as there is probably no one study connected with a skiametrist's educational equipment which demands a more perfect mastery than does that of the *reducing, transposing and combining* lens values. In his desire to attain perfection on the practical side of adapting glasses to the eyes of others, the student is apt to pass hurriedly by the dry underlying optical principles upon which lenses are based and, as a consequence, after his first few years of "success in every case" his desire to climb higher is interfered with through his lack of knowledge of that which he ought to have learned at the beginning of his optical career.

In ocular skiametry a simple stumbling block to many students is their inability to tell what the true refraction of their patient's eye is, when it takes an ordinary lens quantity of, say, one diopter to reverse the shadow in one meridian, while only a half-diopter is required to reverse it in the meridian at right angles to this. Especially is this true where the axes happen to be oblique, or where one lens is *plus* and the other *minus*.

Now this is all wrong, for if an optometrist ought to know anything he ought to know all about lenses—how they are made, what *index of refraction* and *spherical aberration* mean, wherein

cylindrical, *spherical* and *ellipsoidal* curvatures differ and, above all, the very best way to combine lens quantities in order to produce the highest degree of central and peripheral vision, together with *angle* and *decentration* for the relief of strain and the production of comfort.

A thorough knowledge of light and lenses is the great key to the achievement of skiametric success. After a student has learned all about the physical side of refractive work the physiologic becomes easier, just as a mathematician who has skipped some fundamental principle finds his higher work puzzling, but where he has covered his ground carefully then his advancement is less difficult.

A very few sittings will give a student the mastery of a skiascopic mirror and enable him to tell the movement of the pupillary shadows, but how to control these shadows by the aid of lenses combined with fixation, and to know the real optical value of the refractive power used, is where one of the greatest of the stumbling blocks in shadow testing lurks, so that those who become discouraged in their skiametric efforts must not blame this grand test, but look, rather, to their own weakness in their lack of adequate optical knowledge and skill.

There is one more point to which attention should be directed, although it can hardly be called a "stumbling block," even though in some cases it seems to act as such. It pertains to an examiner's own vision, which should be such as to enable him to see with definition a moderately pale shadow on a pink background at a distance of at least forty inches. Therefore all examiners having *myopia* should have their own refractive errors corrected to within less than one diopter before they attempt skiametric work. All *hypermetropes*, on the other hand, whose amplitude of accommodation at thirteen inches is less than their error of refraction must also wear their correcting lenses before they can make satisfactory shadow tests, and this applies, too, to *presbyopes* who should wear their reading correction

when using the mirror at near points. It would seem, however, that the peep-hole in a skiascope ought to act as a pinhole test and give an examiner good vision no matter what his refractive error might be, but experience, that great teacher, rules it otherwise in those cases where high-class results are sought for.

Some examiners have found difficulty in keeping the peep-hole of a skiascope exactly in front of their fixing eye, and thus obtaining a good reflex. This is usually due to their inability to close the unused eye, hence practice in this respect is important, for if one eye is in use the other should be occasionally closed in order to make sure that the fixing eye is properly located.

CHAPTER II.

PROPER AND IMPROPER EXAMINATION ROOMS.—SIZE, INTENSITY AND CONTROL OF ILLUMINATION.—THE PLANE SKIASCOPE, HOW TO HANDLE IT, AND SOME NOVEL INVENTIONS.

EXAMINATION ROOMS. Since the fitting of glasses "over the counter" has practically passed away, the consideration of where the fitting should be done is now in order.

To describe an ideal examination room is quite a different matter than it is to attempt the description of an adequate apartment that might serve fairly well as a place in which to practice ocular skiametry.

The complaint which is frequently heard from many who attempt to do refraction work without having suitable place and apparatus is that they lack the requisite space, whereas an examination of the store or office by one experienced as to requirements might lead to the discovery of quite a number of places which could be rendered available by the use of properly strung wires for hanging light-proof curtains, and which could also be made decorative in appearance. Then, too, many are persuaded that an examination room must be of Egyptian darkness, without ventilation, where both examiner and patient will be very uncomfortable, especially during warm weather.

Now this is a wrong conception. An adequate examination room needs to be of only semi-darkness, in fact if it is just light enough to make the headlines of an ordinary newspaper discernible at midday it will be found dark enough for all optometric purposes. The "Mahomet and the mountain" principle can be made use of by increasing the intensity of the light

source, instead of making the room appear as dark and gloomy as the interior of a hearse.

The space occupied need not be very wide. The length of room, however, ought to be at least twenty feet, but where this distance cannot be obtained a length of ten feet can be made to appear as twenty by the use of an ordinary wall mirror, test cards with reversed letters being placed over the head of the patient in a position where their reflection can readily be seen in the mirror.

The ventilation should be perfect, and the space ought to contain several chairs for the use of those who accompany the patient, while the surroundings should be made as cheerful as possible by means of rugs, pictures, etc.

Both *objective* and *subjective* tests should be used without having to move the patient from the chair in which he is first seated, it being better to bring all instruments and devices to the patient rather than require the patient to go to them.

First impressions are said to be lasting, so that if patients are shown into apartments that look as though they were intended for optometric purposes their confidence is more than half won.

There is a fitness of things, and those whose practice is in accord with this "fitness" generally have occasion to feel satisfied with the results obtained from having given attention to the details of environment. Indeed, it has already been said by many that next to professional knowledge and skill a well appointed examination room is the very best kind of an advertisement an optometrist can have.

SOURCES OF ILLUMINATION. The reader's attention is called to the importance of using a proper source of illumination in order to succeed in shadow testing. Therefore it will be the purpose here to describe, with the assistance of drawings and photo-reproductions, some of the various lamps

employed for this purpose, and to offer criticisms regarding the advantages and disadvantages consequent upon their use.

Practising skiametry by means of a *schematic eye* is very easy in comparison to practising it upon a living eye, for with a model eye almost any kind of light will answer, but not so with the living organ where the light source should resemble the glow emanating from the "glory-hole" of a furnace.

Oil lamps of all types, while many are magnificent for general lighting purposes, fall away below the standard of efficiency when employed for general skiametric uses. The draught in almost all lamps is an important factor, and as metal chimneys cannot be easily made to take the place of glass ones, on account of the transparent aperture which is required opposite the flame, it has been found necessary to either line or cover all glass chimneys with an opaque substance which extreme heat cannot affect. But even where the chimney is lined with a white pigment it still falls short of giving satisfaction as an efficient illuminator, although the maker may claim that his lamp has a general efficiency of over one hundred-candle power.

The reason for the shortcomings of oil lamps, even those using a so-called "flame spreader," is due, no doubt, to the fact that the flame, though large, is apt to be very low, and when its general intensity is hooded down to the size of a two or three centimeter aperture, which is necessary in order to obtain good results with a plane mirror, the flame is found of insufficient brightness to meet an examiner's needs.

Perhaps some day some inventive mind will devise a condensing reflector which will permit of hooding the light of oil lamps down to a small aperture and at the same time obtain the requisite intensity of illumination, but as yet this has not been achieved.

Next to oil comes gas. And here the field of illumination broadens, thanks to the inventors of the "Argand" and "Welsbach" burners, and to the gas-generating qualities of naphtha

and of acetylene. Ranking above oil burners comes the Argand gas lamp, which also requires a draught to make it burn properly, hence a glass chimney is necessary for its use.

But while the Argand gas lamp is vastly superior to oil lamps in general, it is still somewhat below the required standard of efficiency, even when working at its best. The flame has a yellowish white appearance and seems, like the flame of an oil

FIG. 3.



ACETYLENE GAS LAMP WITH METAL CHIMNEY.

lamp, to lack the illuminating energy necessary to meet modern skiametric needs, although in favorable cases fair work can sometimes be done by its aid.

Acetylene lamps represent another style of gas burners which in point of intensity of illumination can probably hold their own against all competitors. The style shown in Fig. 3 represents a portable type.

This lamp is similar in appearance to an ordinary table lamp, with the exception that it has an asbestos lined metal chimney. It is commercially named an "Electrolite gas lamp," and uses pulverized calcium carbide. Its use is endorsed by the board of fire underwriters, and it is easy to care for. The light it gives is over fifty-candle power, while the expense of maintaining it is only about one cent an hour.

FIG. 4.



ASBESTOS LINED METAL CHIMNEY.

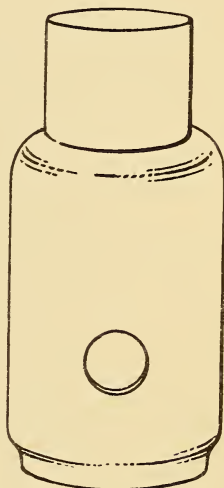
Skiametrists are certainly to be congratulated on the invention of this lamp, especially those who are compelled to do work away from their properly appointed examination rooms, for as a portable lamp it is very satisfactory.

In point of brilliancy, reliability, cost of maintenance and ease of adjustment, however, no gas lamp is superior to the

Welsbach type, especially with a metal asbestos lined chimney, as shown in Fig. 4.

This burner is of the "Incandescent" kind wherein chimney draught, as with oil burners, is not so much of a factor. A glass chimney, however, gives better results than a metal one does, due to the fact that the light aperture is covered, thus preventing an inrush of air which can interfere with the white heat of the

FIG. 5.



ASBESTOS LINED GLASS CHIMNEY.

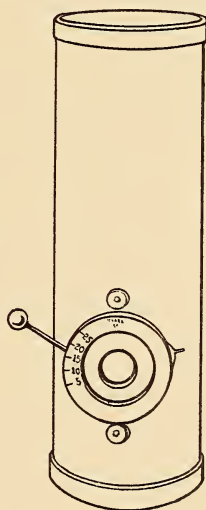
mantle. Figs. 4 and 5 show two patterns of chimneys, one metal and the other glass, which can be used on the same style of burner.

The Fig. 5 chimney being further away from the mantle, the sides do not get as hot as in the pattern shown in Fig. 4, which is made in both glass and metal. But the smaller the chimney the more convenient is the adjustment of the light, the source of

illumination being nearer to the surface, therefore Fig. 4 is to be preferred.

In Fig. 6 is shown an asbestos paper chimney cover, with iris diaphragm opening. This cover can be used outside of an ordinary glass chimney, and serves the purpose of a light screen very well, although it has the faults of the chimney shown in

FIG. 6.



ASBESTOS PAPER CHIMNEY COVER WITH IRIS DIAPHRAGM
OPENING.

Fig. 5 as to size. The iris diaphragm, also, seems to be an unnecessary arrangement, for it is the size of the skiascopic mirror that regulates the facial area of illumination and not the size of the chimney aperture, unless a condensing lens is used, which would indeed be troublesome.

The Welsbach lamp gives an ideal light for shadow testing,

as its flame is bluish-white, while its intensity is ample, especially when its mantle is evenly heated to incandescence. The one unfavorable criticism which can be made regarding it is the fragile character of its mantles, which are easily injured or destroyed. But fortunately these mantles are inexpensive and are not difficult of adjustment.

In connection with naphtha, or gasolene, the Welsbach burner can also be used, but while the light obtained is not as satisfactory as where so-called "City" gas is employed, yet the results secured are vastly superior to the use of oil. The general use of gasolene has its disadvantages, resulting from its explosive qualities. This is a question, however, on which the

FIG. 7.



SPIRAL FILAMENT IN ELECTRIC LAMP.

makers of gasolene lamps and the fire insurance companies are not at all in accord. But as efficient illuminators for skiametric uses, gasolene lamps, using the Welsbach type of burners, will be found more satisfactory than oil, provided they are kept in perfect order.

Wood alcohol is now being extensively used for lighting and heating, so there is every reason to believe that lamps suitable for optometric purposes will soon be devised where this illuminant can be employed.

Electric lamps of the general house-lighting variety, with long carbon filaments, are perhaps among the most unsatisfactory of all illuminators for use in connection with ocular ski-

ametry, no matter whether the glass bulbs are of the clear or the frosted variety.

An electric lamp, to be of service in this work, must have its filament in compact form, similar in shape to the coils of a watch hairspring. Then the light energy of the carbon wires when heated to incandescence can be concentrated, and the results obtained made superior to the mantle type of gas lamp. Fig. 7 shows an electric lamp filament of the spiral kind referred to. This lamp needs to be handled with great care, since owing to the size and brittle character of its filament it becomes easily broken by a sudden jar, or through rough handling in the mail, or when shipped by express.

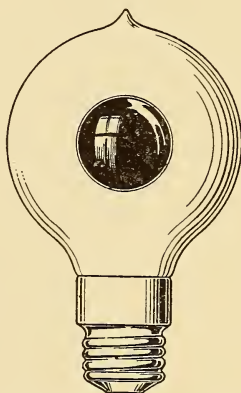
Fig. 8 shows this same lamp with its glass bulb coated with a thick asbestos pigment, leaving a one-inch aperture in its side through which the light can emerge.

This lamp is rated at fifty-candle power and gives a magnificent reddish white light. The white hot filament, or carbon wires, generate considerable heat which, of course, will melt the rubber or composition socket handle if the lamp happens to be used upside down. The heat from one of these lamps has been known to char the curtain hangings of a window, with which it came in contact. But used as it is intended to be used, this style of lamp certainly supplies an adequate illumination for any kind of examination room, whether light or dark, or where gas cannot be obtained, such as in modern office buildings, but once used, an examiner is rarely ever satisfied with any other form of lamp. Most high candle-power lamps, however, are somewhat expensive and burn out easily, they should therefore never be burned for long periods of time but be turned off and allowed to cool as frequently as possible. A snap switch in place of the ordinary socket key should be used, and a lamp ought never to be burned on a current that is of a higher voltage than that for which the lamp is made.

Attention to these details will often prolong the life and serv-

ice of a lamp two or three-fold, for when the inside of the lamp bulb shows a reddish deposit on the glass it indicates decomposition of the carbon filament, due to overuse, or abuse of some kind.

FIG. 8.



AUTHOR'S ASBESTOS COVERED ELECTRIC LAMP.

The cost of maintenance of an electric lamp, too, is somewhat higher than the mantle-type of gas lamp, and its durability is not as great. Any increase in current, even of only a few volts, such as frequently occurs in cities where it is intensified at sundown, serves to shorten the life of a lamp very materially. These uncertainties of current can be controlled by what are called resistance attachments, or rheostats, if an examiner cares to incur the expense. The superior light given by these high candle-power electric lamps, however, more than compensates for the trouble and expenditure their use entails.

Another form of electric illumination, and one which has the added advantage of portability, is the combined lamp and mirror, known as the *luminous* type of retinoscope. Fig. 9 illustrates the appearance of a late model of one of these instruments, for which the makers put forth the following claims:

"This self-contained Electric Retinoscope, combining as it does the battery, lamp, mirror and illuminated fixation letters, leaves nothing to be desired in an instrument of this kind. It offers tremendous advantages in every branch of Retinoscopy. It can be used in any place or position irrespective of circumstances.

"The Jumbo Handle Battery shown is designed to meet the demand for a very compact and portable instrument of maximum endurance. It is made of aluminum and is designed to hold a two-cell battery of regular stock size. This handle is well proportioned, is convenient to hold and has a compressible circuit breaker conveniently located for the thumb of the operator. It is arranged for either a touch or a fixed contact, the lamp being lighted either by pressing the extending arm against the handle or swinging it around in contact with the clip on the top of the cap as desired.

"The Illuminated Fixation Letters, appearing to the left of the mirror, are invaluable in the Dynamic System of Skiascopy.

"They are clearly cut in white against a black background, and being located in close proximity to the mirror, the refraction can be estimated almost at the macula. These letters are rendered visible in the dark room by a divergent shaft of light which passes through an opening in the tube containing the lamp, which illuminates the mirror. This coincident illumination of the mirror and

FIG. 9.

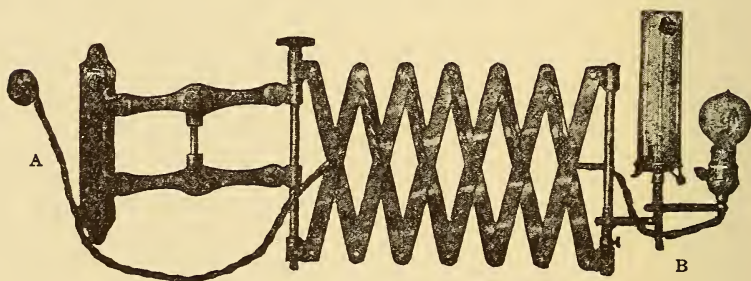
DE ZENG ELECTRIC
RETINOSCOPE.

fixation letters obviates the necessity of any extraneous light, thereby affording the operator the advantage of a perfectly darkened room when so desired."

The lamp used is of only one or two-candle power and is located behind, and close to, a strong convex lens, which serves to parallel the light radiation and thereby avoid any waste due to this cause, but like other electric lamps it, too, is sensitive to abuse.

The light it gives is a fairly intense one and enables good work to be accomplished by those who are acquainted with its

FIG. 10.



THE "HARDY" WALL BRACKET FOR GAS OR ELECTRIC LAMP.

peculiarities. For *dynamic* work its fixation letters are limited in both numbers and position.

As a portable light it is compact and easy of transportation and, in an emergency, serves the purpose of being useful as an ophthalmoscope as well.

A point to bear in mind in connection with adequate illumination in skiametric work is to have whatever lamp may be used so arranged that its *adjustments*, forward and backward to and from an examiner's own eye, are readily obtainable. The adjustment as to height is not so important as long as the light is

about level with the patient's head and is situated from six to twelve inches to the patient's right. The alterable distance forward and backward is, however, quite essential, as it enables the intensity of illumination to be controlled by an examiner as his case demands. A very simple way to arrange for this is to use a wall bracket similar to the one shown in Fig. 10.

This bracket is arranged for gas and electricity, and thus gives an examiner a double system of illumination which, in case of necessity, may prove of very great value in preventing a break-down.

In summing up the question of illumination, perhaps the expression from the pen of a western specialist will serve to state the case fairly well. He wrote, "*I fully realize that proper illumination is the foundation of success in skiametry.*" And it may be added that this opinion is shared by many others who have had experience.

VARIOUS SKIASCOPES. The confusion following the use of two forms of skiascopes, such as those having *plane* and those having *concave* mirrors, has led to the virtual abandonment of the latter by most of the skiametrists of the country. There are possibly some conditions under which a *concave* reflector might give an examiner better service than a *plane* one would, but these are rare, and for general all-round skiametric purposes the *plane mirror* is to be greatly preferred. All mirrors should be as brilliantly silvered as possible, and the reflections from them ought to be perfectly round and free from distortion.

Regarding the size or working part of a mirror, this can be easily determined by holding it at the maximum distance at which it is to be used and covering its periphery with washer-like pieces of paper. The size of the reflecting surface necessary to produce the best results while in actual service can then

be noted. This will usually be found to represent an area of about three-quarters of an inch in diameter.

The central aperture, or peep-hole, should be as small as possible and yet permit of acute vision on the part of the examiner. A diameter of one or two millimeters is generally sufficient for the purpose. Having the handle at least six inches long will be found especially advantageous in using body movements.

Keeping the peep-hole free from dust and dirt is also important. A frequent twist of the skiascope just before it is used, and while its front and back are covered with a handker-

FIG. 11.



A SIMPLE SKIASCOPE.

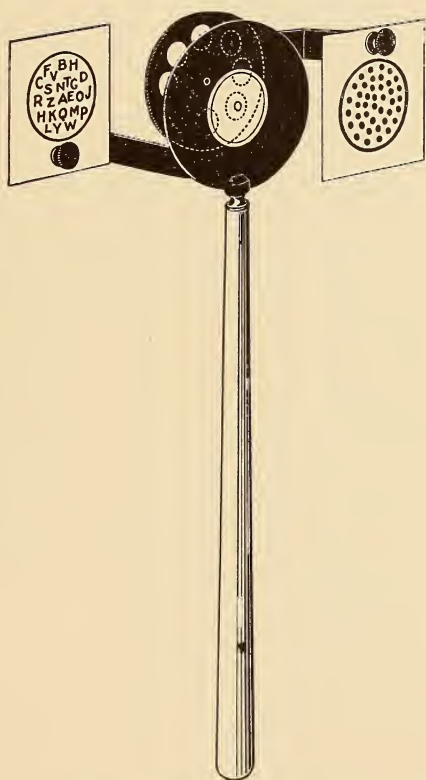
chief held between the thumb and forefinger of the operator's hand, is usually all that is necessary in order to keep it quite clean.

Fig. 11 represents the skiascope generally employed in the practice of what is usually called "retinoscopy," where accommodation is supposed to be relaxed by having the patient look over the examiner's shoulder, or where "*a reliable cycloplegic*" has been used.

As will be seen in subsequent chapters, the use of cards for fixing the vision of the patient at the same distance away as that

at which the mirror is operated renders some means for attaching cards to the skiascope almost a necessity. Fig. 12 shows a device to which the name "Double Bracket Skiascope" has been

FIG. 12.



AUTHOR'S DOUBLE BRACKET SKIASCOPE.

given. The lenses in the disc at the back of this skiascope contain plus spherics of 1. D. 1.50 D. 2. D. 2.50 D. 3.D. 4.D. and 5. D. for the purpose of correcting any *presbyopia* that an

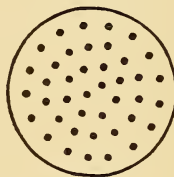
optometrist may have, himself, while working at any distance less than forty inches, so as to obtain a clear view of the action of the shadow. When an examiner is under forty-five years of age the use of this lens disc is seldom required.

The arrangement of the brackets attached to the mirror frame are such that the cards can be given a number of adjustments to suit possible contingencies. Also for the purpose of maintaining fixation so it can be relied upon, for variation in fixation means, of course, an alteration in the patient's refraction. The usual procedure is for the examiner to request that the irregularly placed letters on the fixation card, Fig. 13, be

FIG. 13.



FIG. 14.



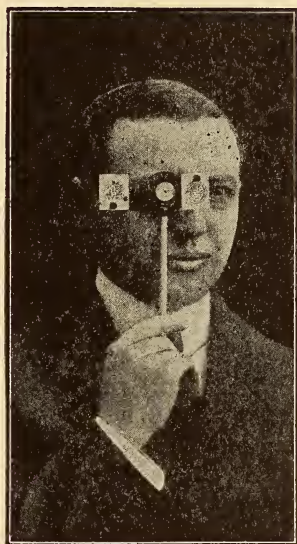
SKIAMETRIC FIXATION CARDS.

counted by the patient. Then, if this does not prolong the fixation period sufficiently, the request is made to state what letters of the alphabet are missing, or what letters appear more than once.

If the visual angle needs changing, or the focal fixation requires slight alteration, then the other fixation card, Fig. 14, can be made use of, reliable fixation being maintained by disputing the patient's count of the dots. The position of the Fig. 13 card also has an advantage in its being placed so as to correspond with the examiner's own nodal point. When the light source is found unpleasant to the unused eye of an examiner it may be obviated by having card, Fig. 14, made longer and adjusted so as to act as a screen.

HANDLING THE PLANE SKIASCOPE. Regarding the proper way to handle a skiascope, the various tutors in skiametry differ, but all agree that the movements of the mirror should be of the slow, steady, straight-line order, and as free from wobbling and semi-circular motions as possible. When movements of the mirror are attempted by the hand-

FIG. 15.



MANNER OF HOLDING AUTHOR'S SKIASCOPE.

tilting method it takes many years of practice before a positive straight-line motion in all meridians of an eye can be depended upon. But where the movements are made by a body-tilting method the mastery of the mirror is very rapid, some beginners acquiring it almost perfectly after only a few days of practice.

A description of this body method is as follows: The mirror handle is to be grasped near its lower end, when the skiascope is

held in a vertical position. The elbow and arm of the hand holding the mirror are to be pressed tightly against the side of the body, while the upper and inner edge of the metal disc, upon which the mirror is mounted, is to be held firmly against the side of the examiner's nose or resting on the eyebrow in such a manner that the peep-hole of the mirror is exactly in front of the operator's pupil. With the mirror handle held in a rigid manner, almost the entire body is made to assist in giving the proper movements. The examiner's upper torso, or trunk, acts as though it was pivoted at the waist, while the neck and heaving chest aid in the necessary motions. To say that this action involves a sort of courtesy, or bowing movement, might perhaps add to its description. Fig. 15 may also serve to give a better idea of how the skiascope should be held.

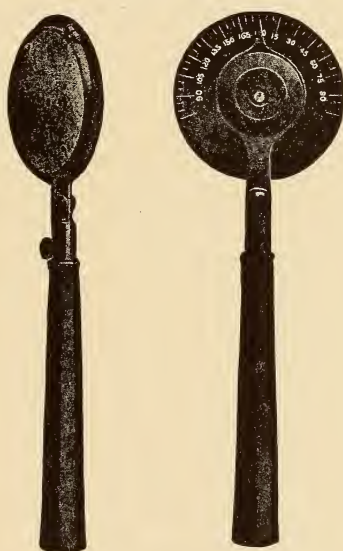
It is always better for an examiner to learn to work with both eyes open when locating the reflected light on the face of a patient. After this location, the eye not in use at the peep-hole should be closed, so as to stimulate concentration and sharpen the brightness of the fundus reflex, as well as to define the shadow's edge. The closing of the unused eye serves to obviate any discomfort an examiner may experience, caused by the glaring light from the lamp in use, and especially so if the latter is at close range.

The mirror light on the patient's face ought not to move over an inch in any one direction, and the pink pupil should hardly ever be allowed to pass entirely from view after once being found. The examiner should direct his attention to one edge of the patient's pupil only, as in this way he can quickly determine whether the shadow is *with* or *against* the mirror's movement in any one meridian. All movements should also be made very slowly, since rapidity of motion often interferes with judgment as to the shadow's action, just as the spokes in a wheel are found to be more difficult to count when the wheel revolves rapidly than when it goes slowly.

NOVEL SKIASCOPES. Among the novel devices for shadow seeing can be mentioned the Reisner "Retinoscope," shown in Fig. 16.

The claims for this instrument are set forth by the manufacturers as follows:

FIG. 16.



REISNER'S RETINOSCOPE.

"The Reisner Retinoscope has a small lever for tilting the mirror mechanically with self-recording axis on back. Tilting a mirror mechanically instead of the old way gives a positive movement straight across the meridian being neutralized, thereby avoiding the circular motion common with the ordinary mirror, enabling an operator to determine definitely the difference between a case of conical cornea and mixed or irregular astigmatism. Referring to the back of the instrument, the

number indicated by pointer represents the axis at which lens should be placed in frame."

Another departure in retinoscopes is the Klein "Non-Irritating Retinoscope," shown in Fig. 17.

The mirror of this instrument is made of amber glass silvered and mounted in the usual way. The makers ask the following pertinent question:

FIG. 17.



KLEIN'S RETINOSCOPE.

"Why continue to use the ordinary white glass retinoscope, and cause needless annoyance to your patients, when, for a little more, you can obtain Klein's Non-Irritating amber glass retinoscope? This instrument is monochromatic, reduces the actinic rays, *insures from ten to twenty per cent. greater dilation of the pupil* and minimizes the diffused rays, which are annoying in the reflex of many eyes."

CHAPTER III.

SCHEMATIC EYE PRACTICE AND ITS IMPORTANCE TO STUDENTS.

—MODEL EYES AND THE EXERCISE OF CARE IN THEIR ADJUSTMENT.—REDUCTION AND TRANSPOSITION OF LENS VALUES, AND THE NECESSITY FOR THE COMPLETE MASTERY OF THIS WORK IN SUCCESSFUL SKIAMETRY.

SCHEMATIC EYE PRACTICE. *Skill* is called "familiarity with and dexterity in the execution of any science, art or handicraft," and no division of optometry calls for more practical work, in order to be skillful, than does skiametry.

It is exceedingly tiresome to a patient to sit quietly and have some inexperienced student gaze for minutes through the peep-hole of a mirror because he is unable to correctly determine the shadow's action. But with an experienced examiner it is different, all he needs is one or two flashes, or excursions of the reflected light, and the behavior of the shadow, under usual conditions, is made plain.

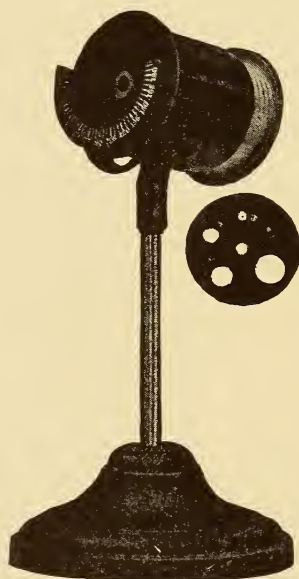
Skill in this work can only come through experience, and experience gained through the use of a metal or paste-board model eye is just as valuable to the student as though it was gained through looking into a living organ of vision.

Students can begin with large ocular pupils, and then, as their skill increases, these pupils can be made smaller and smaller. The expert in any field where skill is a factor is the one who practises morning, noon and night, or at every opportunity that presents itself.

Human eyes, owing to variations in the pigmentation of the fundus and to the uneven thickness of the corneal tissue giving rise to what is called "irregular" astigmatism, are factors

that make some living eyes most difficult to measure by means of the shadow test, so if an examiner makes himself a thorough master of the model eye, where conditions can be made ideal, he will have far less trouble with living eyes than if this preliminary practice on the model eye has been neglected.

FIG. 18.



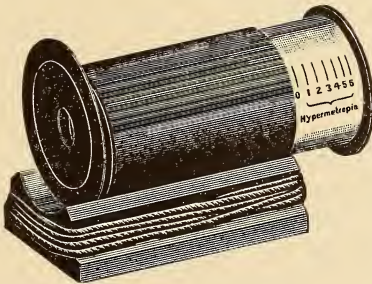
THE "DE ZENG-STANDARD" SCHEMATIC EYE.

SCHEMATIC EYES. For research work, as well as for practise, a good schematic eye requires careful selection and adjustment. The metal and pasteboard models that are on sale in all first-class optical supply houses offer a most excellent means for beginners to familiarize themselves with the principles of both *skiametry* and *ophthalmoscopy*. These eyes, however, are frequently imperfect in construction, and the printed

scales attached to them are often unreliable. As a consequence, the student is apt to meet with discouraging results in his initial efforts to use them. Fig. 18 shows one of the newer makes of the all-metal kind, which has five sizes of pupil.

The backs of these eyes are arranged for the insertion of colored miniature plates, which serve to illustrate the various pathologic conditions of the retina, and are to be used in connection with the study of *ophthalmoscopy* and the use of the ophthalmoscope. The double cell in front of the model eye makes it of excellent service in skiametric practice; as the well

FIG. 19.



QUEEN'S PASTEBOARD SCHEMATIC EYE.

marked axis scale also aids a beginner in obtaining the meridional accuracy which is so necessary to good work.

The cheap pasteboard model, such as shown in Fig. 19, is usually found to be almost as trustworthy as the more expensive ones, but all of them require testing before their findings can be implicitly relied upon.

A good way to determine the accuracy of these models for skiametric purposes is to have an experienced skiametrist put them to actual test by first setting the scale at "0," and then, if a one-diopter convex spherical lens causes a reversal of the shadow in all meridians at exactly forty inches away, it is quite

safe to rely on other findings made by means of the same model. To prove, however, that the scales are properly spaced it is wise to first test a few of the numbers on each side of the "o" before depending upon them for accuracy, for in optometric work in general it is so easy to be wrong and so difficult to be *precisely* right.

All kinds of ordinary errors of refraction can be artificially created by means of these model eyes together with a few trial lenses. For instance, if an examiner is operating at a distance of forty inches away, by setting the model so that it shows one diopter of *myopia* and then by adding a one-diopter concave *cylindric* lens, he can create an error of one diopter of *hyperopic astigmatia*. A one-diopter convex *cylinder* can be used to produce *myopic astigmatia* of equal amount. Setting the model to show two diopters of *myopia* and then using a one-diopter convex *cylinder* lens will create a compound error of minus one-diopter *spheric* combined with a minus one-diopter *cylindric*, due allowance of one diopter having been made for the working distance.

With the model showing two diopters of *hypermetropia*, if a two-diopter concave *cylindric* lens be added, the exact compound quantity represented by this error would be plus two diopters of *spheric* combined with plus two diopters of *cylindric*. And to neutralize it skiametrically at a distance of forty inches away would require an added lens power equal to plus three diopters *spheric* combined with plus two diopters *cylindric*. The added diopter of plus *spheric* representing *the false myopia*, often called the "working quantity."

To illustrate a mixed astigmatic condition the model can be set to show two diopters of *myopia*, and then by adding a minus two-diopter *cylinder* at axis 90 an error representing minus one-diopter *cylinder* axis 180 combined with a plus one-diopter *cylinder* axis 90 can be obtained, which would require the addition of this lens quantity, or its equivalent, to neutralize it by means of the one-meter shadow test. And it will be noted

that at whatever axis the cylindric lens is set the axis of the artificial astigmatism will be in the same meridian. Thus it will be seen that a schematic eye can be made a very useful and patient patient.

REDUCTION OF LENSES. In practical examination-room work with the skiascopic mirror it frequently happens that a saving of time and trouble is effected by making a test right over the patient's own glasses; this test resulting, perhaps, in the discovery that a compound-lens quantity needs to be either added to or subtracted from the lenses then in use. Upon neutralizing these glasses it is found that they, too, are of the so-called "compound" type, therefore an examiner must be possessed of knowledge that will enable him to tell the exact ray-bending power of the four lens quantities involved and to do it with ease and without waste of time or likelihood of making mistakes. Now while this subject is not classified as belonging to *theoretic* skiametry, yet it is, nevertheless, a very important factor in contributing toward successful shadow work, and especially so in connection with the *dynamic* method, for skiametry is sometimes considered as *neutralization at long range*. Therefore a few pages will here be given to what is thought to be a very simple solution of a so-called *complex* subject.

In the consideration of most problems there is the unit or lowest appreciable quantity to be dealt with, so it is with lenses. Speaking *microscopically* the basis of all lenses can be said to be *prisms*, but speaking *macroscopically*, the unit of all lenses is a *cylinder*. Therefore, if it is learned how to combine these cylinders, after having reduced all lens quantities to a cylindric basis, the transposition of lenses will be found to be a very easy task, no matter whether the lens quantities dealt with number few or many.

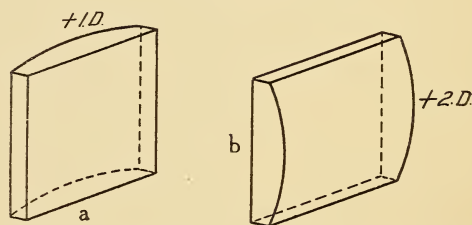
This principle is much like the one in the old story related of the quack doctor who had two bottles of medicine with

which he could cure all the ills that flesh was heir to. His plan was to give doses out of one bottle which turned every ailment into fits, then the remedy in the other bottle cured the fits, and the patient got well.

To carry out a similar procedure it must be considered that two *cylindric* lenses of like *kind* and *strength* when crossing one another at right angles are equal to a *spheric* lens. Hence the reverse follows, that a *spheric* lens is equal to two *cylindric* lenses crossing one another at right angles, and whose *kind* and *strength* are the same.

In the optometrist's consideration of cylinders he will never need them at any other than at right angles to one another, no

FIG. 20.



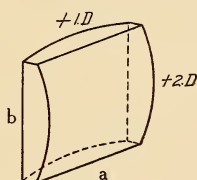
TWO CYLINDRIC LENSES OF UNEQUAL FOCUS AND AXIS.

matter whether they are *plus* and *plus* or *minus* and *minus*, of the same or unequal strengths, or whether they are *plus* and *minus* or *minus* and *plus*, equal or unequal, etc., etc. Their axes will always be at right angles, and for the simple reason that if they were crossed at any other than *right* angles their combined refraction would show a *sphero-cylindric* effect, which could be duplicated by right-angle cylinders.

Now, in a combination of *cylindric* lenses of *unequal strength*, but of the same *kind*, it will be seen that when their axes are at right angles to each other their combined refraction will be equal to that of a compound lens whose component parts

are of a *like* nature: as a plus one-diopter *cylinder* set at right angles to a plus two-diopter *cylinder* is equal to a plus one-diopter *spheric* combined with a plus one-diopter *cylindric*. The second *cylinder* in the above case having been robbed of a quantity equal to the strength of the first *cylinder*, in order to

FIG. 21.

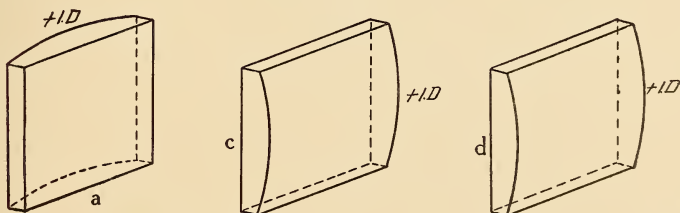


A CROSSED-CYLINDER LENS OF UNEQUAL MERIDIONAL FOCUS.

convert the first one into a *spheric* quantity. The robbery is noted and due allowance made therefor.

By referring to Fig. 20 it will be seen that the cylinder lens "a" has a ray bending power of plus 1. D., while cylinder lens

FIG. 22.



THREE CYLINDRIC LENSES OF EQUAL FOCUS. ONE AT AXIS 90 AND TWO AT AXIS 180.

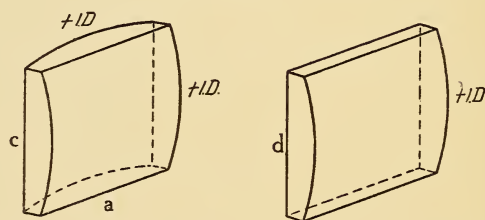
"b" has a power of plus 2. D. Their axes, of course, are at right angles to each other, also to their ray bending power. If these two lenses were merged back to back their appearance would be illustrated by Fig. 21.

Instead of *two* cylinders being used, one plus 1. D. and the other plus 2. D., it is shown in Fig. 22 that *three* plus 1. D. cylinders can be employed to accomplish the same purpose as those in Fig. 20.

In Fig. 23 it is shown that lens "a" has been converted into a 1. D. *spheric* quantity by the use of the borrowed lens "c" of Fig. 22, and as it takes "c" and "d" to equal the plus 2. D. of "b" in Fig. 20 it is plain that "d" is the remaining quantity. Thus the formula:

+ 1. D. C. axis 90 $\bigcirc$ + 2. D. C. axis 180 equals + 1. D. S. $\bigcirc$ + 1. D. C. axis 180.

FIG. 23.



ONE CROSSED-CYLINDER OF EQUAL MERIDIONAL FOCUS AND ONE SIMPLE CYLINDER AT AXIS 180.

Except for purposes of analysis, the *crossed cylinder* is never to be generally employed, he who prescribes it otherwise only exhibits his ignorance of lenses and their uses, as the function of a lens is to bend rays of light, and it matters little whether this bending is done by two cylinders crossing one another at right angles or whether it is accomplished by means of a lens where one surface has a *spheric* curvature. This rule also applies to "toric" lenses where the curves of one surface of revolution are ellipsoidal in character, made so by having one meridian of curvature either greater or less than the one at right angles to it.

To crowd an examiner's head with arbitrary rules is likely to lead to confusion, so that in the case of transposing lenses it is well to simplify the process as much as possible. Therefore, in imitating the method of the quack doctor with his two medicines, it will be necessary to first reduce all lens quantities to a *cylindric* basis and then commit to memory two short rules for the transposition of cylinders. The following extra long combination may, perhaps, serve to make this reduction principle plainer:

+ 1. D. S. $\ominus$ + 2. D. C. 90 $\ominus$ - 1. D. C. 180 $\ominus$ + 1. D. S. $\ominus$ - 2. D. C. 90 $\ominus$ - 2. D. S.

Here, it is seen, there are six lens quantities whose chief *axes* are 90 and 180 degrees. After creating two columns, all of the lens quantities are written in their *cylindric equivalents* whose axes come under these two headings, not forgetting that each *spheric* lens is to be written twice as it is equal to two *crossed cylindric* ones whose *strength* and *kind* are the *same*. The following is then obtained:

<i>Axis 90</i>	<i>Axis 180</i>
+ 1.	+ 1.
+ 2.	- 1.
+ 1.	+ 1.
- 2.	- 2.
- 2.	
0	- 1.

In the axis 90 column the totals are + 4. D. and - 4. D., which, of course, neutralize one another. In the axis 180 column the totals of - 3. D. and + 2. D. leave a remainder of - 1. D. axis 180.

Take this example for instance:

+ 0.50 D. C. 45 $\ominus$ + 0.25 D. S. $\ominus$ + 0.25 D. C. 135.

Here the two chief axes are 45 and 135 degrees, and proceeding as before the results are:

<i>Axis 45</i>	<i>Axis 135</i>
+ 0.50	+ 0.25
+ 0.25	+ 0.25
+ 0.75	+ 0.50

The totals give one cylinder of + 0.75 axis 45 to be crossed by another cylinder of + 0.50 D. axis 135, the *symbols* being *alike*.

Now another example in *reduction*:

+ 1.25 D. S. $\subset$ — 1.75 D. C. 15 $\subset$ — 0.75 D. S.
 $\subset$ — 0.25 D. C. 105.

Being reduced, the results obtained are:

<i>Axis 15</i>	<i>Axis 105</i>
+ 1.25	+ 1.25
— 1.75	— 0.75
— 0.75	— 0.25
— 1.25	+ 0.25

This gives a total of one cylinder of — 1.25 D. axis 15 being crossed by another cylinder of + 0.25 D. axis 105, the *symbols* being *unlike*.

In the three examples shown all lens quantities have been converted into *cylindric equivalents*, so that in order to master them the two short rules before mentioned must be used for the transposition of these cylinders, and then the simple lesson will have been acquired.

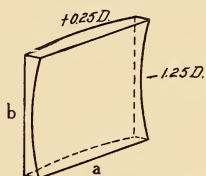
TRANSPOSITION OF LENSES. RULE No. 1.—*In a combination of cylindric lenses of a like character, such as plus*

and plus, or minus and minus, the strength of the weakest cylinder should be written as the spheric quantity while the DIFFERENCE between the two lenses should be written as a new cylindric quantity, the axis of the stronger cylinder governing the axis of the cylinder in combination, thus:

+ 0.75 D. C. axis 45 $\ominus$ + 0.50 D. C. axis 135 should be written as equal to + 0.50 D. S. $\ominus$ + 0.25 D. C. axis 45.

RULE NO. 2.—In a combination of cylindric lenses of different character, such as plus and minus, or minus and plus, the strength of either cylinder can be written as a spheric quantity while the (arithmetical) SUM of the two cylinders should

FIG. 24.



CROSSED-CYLINDRIC LENS OF PLUS AND MINUS CURVATURES.

be written as a new cylindric quantity, the axis of the second lens governing the axis of the cylinder in combination, thus:

— 1.25 D. C. axis 15 $\ominus$ + 0.25 D. C. axis 105,

can be written in two ways, the better way being to write it with the minus quantity first, so as to obtain a *periscopic* effect in the completed lens, this produces:

— 1.25 D. S. $\ominus$ + 1.50 D. C. axis 105.

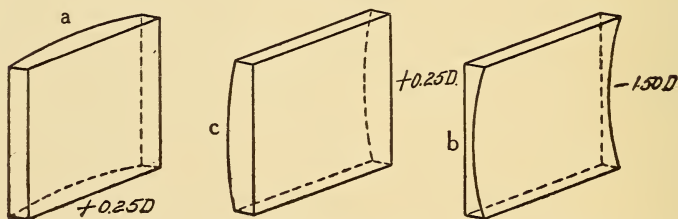
Or an equal refractive quantity can be obtained by writing it in this way:

+ 0.25 D. S. $\ominus$ — 1.50 D. C. axis 15.

Fig. 24 shows a plus 0.25 D. C. lens "a" at axis 90, being

crossed at right angles by a minus 1.25 D. C. lens "b." Fig. 25 shows that the plus 0.25 D. cylinder "a" must be crossed by a plus 0.25 D. cylinder "c" in order to convert the "a" lens into a *spheric* quantity, and that the "b" cylinder must then be increased to minus 1.50 D. in order to produce a ray bending power of minus 1.25 D. after the strength of the borrowed lens "c" has been neutralized.

FIG. 25.



THREE CYLINDRIC LENSES, TWO PLUS AND ONE MINUS.

It will be noted in Rule No. 2 that the word "*arithmetical*" is parenthesized, this is done to indicate that for purposes of common understanding liberties have been taken with an *algebraic* problem.

To re-transpose any of these combinations it is only necessary to proceed by the usual reduction to *cylindric* form and then apply whichever one of the two simple rules that may be called for.

There is one other form of *transposition* which it might be well to mention here, and that is in the changing of *plus* and *plus* and *minus* and *minus* compounds into *plus* and *minus* or *minus* and *plus* equivalents for the purpose of producing *meniscus* forms of lenses. For instance, the following two formulas "a" and "b" have like ray bending powers, also "c" and "d."

a. + 1. D. S. $\ominus$ + 1. D. C. axis 90, or

b. + 2. D. S. $\ominus$ — 1. D. C. axis 180

and

c. — 1. D. S. $\ominus$ — 1. D. C. axis 180, or

d. — 2. D. S. $\ominus$ + 1. D. C. axis 90.

The rule governing this transposition is as follows:

RULE No. 3.—*Add the two lens quantities together for a new sphere, change the symbol of the cylinder and alter its axis ninety degrees.*

The world, metaphorically speaking, takes off its hat to the mathematician, so if the optometrist desires that deference be shown him, too, he must acquire enough of mathematics to make himself proficient in his work.

Procrastination and the plea of "no time to take up higher optics" will neither advance the individual nor the profession to which he belongs. Self-education is just as good as any other kind, provided it accomplishes its object; therefore let him who desires to make substantial skiametric advancement remember that the greatest service he can do himself is to thoroughly master the rudiments of light and lenses and to acquire the ability to juggle with all kinds and quantities of *ray* and *lens* values.

CHAPTER IV.

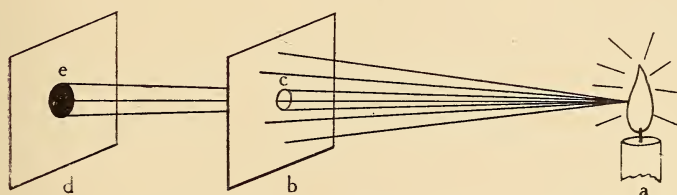
WHY OCULAR PUPILS APPEAR RED WHEN VIEWED THROUGH A SKIASCOPE WITH A BRIEF DESCRIPTION OF THE CARDINAL POINTS INVOLVED IN STATIC SKIAMETRY, AS PRACTISED WITH THE PLANE MIRROR, INCLUDING SOME THEORIES REGARDING FUNDUS REFLEX.

WHY PUPILS APPEAR RED. Before considering retinal illumination it will be well to again call attention to the fact that all visible objects that do not generate light must, of course, reflect it, hence every non-luminous object that can be seen may be considered as being some kind of a mirror. Glass with amalgam backing, as before stated, makes the best reflector, while a dark uneven surface, like black velvet, makes the poorest. With a so-called "looking glass" the rays of light are reflected in an almost unbroken manner, whereas with most visible objects their surfaces are such as to break up the light into irregular rays, or angles of reflection. This breaking up being well illustrated by a lamp having a clear glass chimney, and one whose chimney is of the ground or "frosted" kind. In the clear glass the flame is the true source of light. In the ground glass the surface of the chimney is the *apparent* source.

The inner back part or, so-called, *fundus* of an eye is about the same sort of a mirror as rough red tissue paper makes, and as it is necessary to illuminate this *fundus* in order to obtain an apparent source of light, or target, from which to measure emergent rays, it will be seen that consideration of why the pupil of an eye appears red through the peep-hole of a skiascope will be well for all students to understand, reference is therefore to be had to Figs. 26, 27 and 28.

In Fig. 26 the candle "a" radiates light rays which fall on card "b" and pass through the aperture "c" thus illuminating a portion of card "d."

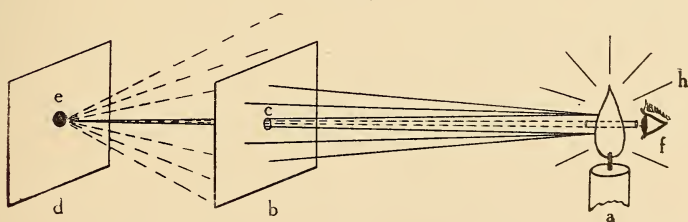
FIG. 26.



ILLUMINATION OF SECOND CARD THROUGH HOLE IN FIRST ONE.

Card "d" being something of a mirror, reflects the light from the illuminated spot, or area, "e" in all directions, some of which, of course, passes back again through the aperture "c" in card "b," as shown in Fig. 27. An eye, therefore, at "f" in

FIG. 27.

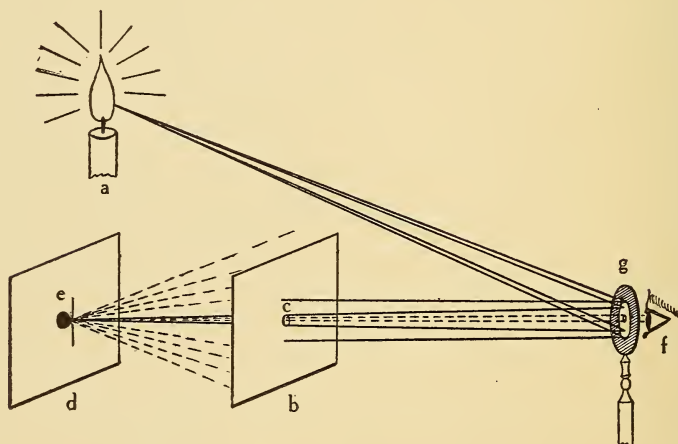


RETURN RAYS FROM SECOND CARD ENTERING EYE THROUGH TUBE IN CANDLE.

order to see the edge, or any portion, of the illuminated area "e" on card "d," must be placed behind a tube "h," which passes through the flame of the candle "a," where it will then be enabled to intercept the returning rays from "e."

In Fig. 28, the skiascope "g," having a peep-hole in the center of its mirror, practically replaces the tube "h," shown in candle "a," of Fig. 27. The eye "f" in Fig. 28 is therefore enabled to see the illuminated area "e" on card "d." Now, by enclosing cards "b" and "d" in the rim of a hollow sphere and placing a lens over the aperture "c" in card "b," there would be

FIG. 28.



SUBSTITUTING A SKIASCOPE FOR CANDLE TUBE.

created the optical principles of a real eye whose pupil would appear red, because the *fundus* of the eye would be visible to an observer. This observer could then readily see the posterior inner surface of the eye where the mesh work of blood vessels gives it the usual pink-like appearance so familiar to the experienced examiner. It follows, therefore, that the reason why the pupil of an eye ordinarily appears black is because returning rays can not be intercepted without using an instrument.

RETINAL ILLUMINATION. *Subjective* optometry can be said to be the treating, or bending, of rays of light *before* they enter an eye, whereas, *objective* optometry can be called the bending of the rays *after* they leave the eye.

Rays entering an eye can be of two kinds, those that proceed direct from some light source, such as a lamp flame, and those that are reflected from some kind of a mirror. In either case the *fundus* of the eye is illuminated, and the intensity of the illumination is dependent upon the distance that the rays have traveled, and to the quality of the mirror that reflects them.

Rays traveling in the form of a beam of light can be made to enter the eye *parallel*, *convergent* or *divergent*, and the size of the retinal illumination is dependent upon this *parallelism*, *convergency* or *divergency*.

Retinal illumination is a necessity in skiametry, because some kind of a *target*, or apparent light source, must be obtained from which the emergent rays can emanate, and the means for obtaining this *target* is to be had by reflecting light from a lamp flame into a patient's eye, and then by intercepting the returning or reflected rays, at the peep-hole of a skiascope, an examiner is in a position to measure these rays and thus to determine the state of the patient's refraction.

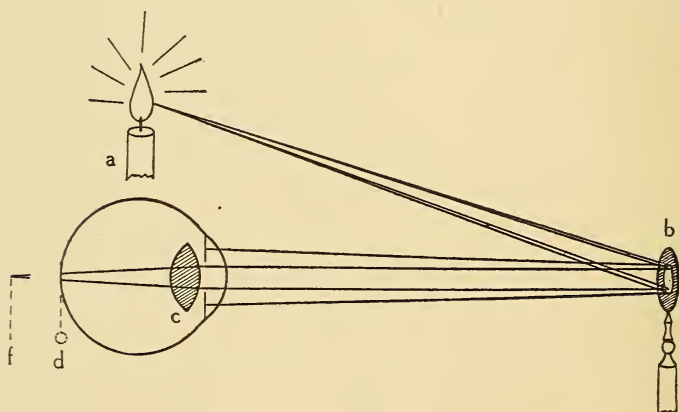
Two factors in skiametric work must be kept in mind, namely, that the entering rays are *solely* for the purpose of creating a *source* from which the emerging rays can start, while it is the *angle of the emerging rays*, alone, which denotes the refractive condition of the eye, and it is the measurement of these *emergent* rays that gives the name of shadow measuring to skiametry. The so-called "shadow" being created by the inner edge of the iris, which limits the size of the illuminated area on the retina, made by the entering rays of light.

Errors of refraction, and the distance from the external light source, serve to influence the *size* of the retinal light spot, and this, in turn, influences the *speed* and *brightness* of the

shadow in its skiascopic behavior, but it has no direct bearing upon the refraction of the eye under measurement, as the *emergent* rays originate from the *internal* light source created by the illumination on the retina, and it is the movement of the edge of this light spot that gives the *with* and *against* motions of the shadow, made mention of later on.

In Fig. 29, "a" is the external light source, "b" is the skiascope, "c" the lens system of the eye, "d" the retinal illumination, or light spot, and "f" the focus of the entering rays, which the retina stops at "d."

FIG. 29.



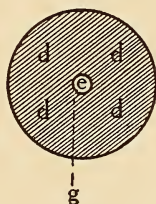
ILLUMINATING THE OCULAR FUNDUS.

The size of "d," it will be easily seen, is regulated by the positions of "a" and "b," for if the light source, or the mirror, is near to the eye then "d" will be larger than if either one were farther away.

Fig. 30 shows the *fundus* of an eye with an illuminated area of light, "e," the shadow being represented by "d, d, d, d," while "g" calls attention to the demarcation between "d, d, d, d," and

"e." This demarcation creating the edge of a *target*, or curved line of light, acting as a *source* from which measurements can be calculated.

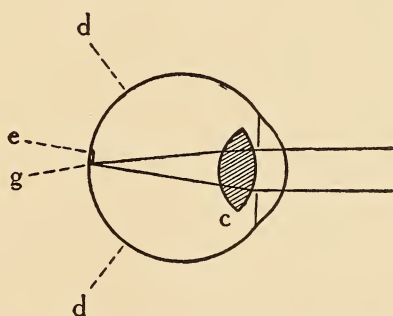
FIG. 30.



THE ILLUMINATED AREA ON THE FUNDUS.

SHADOW PHENOMENA. In Fig. 31 the marginal line "g," between the light spot "e" and the non-illuminated area "d" "d" constitutes the starting point for the emerging rays, and

FIG. 31.



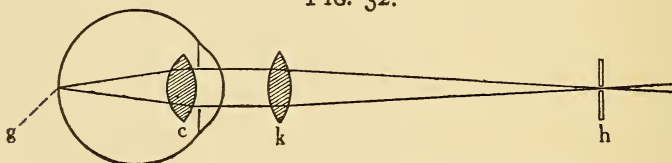
RAYs RETURNING FROM EDGE OF ILLUMINATED AREA ON THE FUNDUS.

if the lens system "c" is in proper relation to the target "g," producing what is known as *emmetropia*, the rays will emerge *parallel*.

On the other hand, if the emerging rays *diverge* or *converge* in one or more meridians of the eye it denotes an error of refraction of some kind.

When a convex lens of known power is placed in front of an emmetropic eye, as shown by "k" in Fig. 32, the emerging *parallel* rays will be brought to a *focus*, or crossing point, at the focal length of the lens used, and if at this focal point an examiner places his own eye behind the peep-hole of a skiascope, at "h," he will be unable to note any motion of "g," or of any appearance of a shadow in the pupil of the patient's eye. On the contrary, if he advances toward the patient so that the point of crossing of the emergent rays is *behind* his own eye,

FIG. 32.



RETURNING RAYS INFLUENCED BY A CONVEX LENS.

then he can note, if he is skillful, that "g" now appears as the edge of a pupillary shadow and moves *with* the movement of the light on the patient's face as he rotates his skiascopic mirror from side to side or top to bottom across the eye. And if the eye is *emmetropic* this movement of the shadow will be alike in all meridians of rotation.

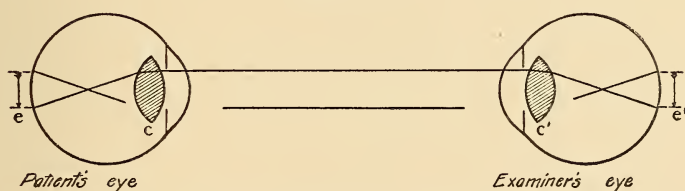
The reverse order prevails if the examiner recedes from his patient, so that the focus, or crossing point of the emergent rays, is *in front* of his own eye, then all rotations of his skiascopic mirror cause the shadow to move *against* the light that is reflected on the patient's face. This crossing point of the emergent rays then becomes known as the "*point of reversal*" of the shadow, and this *reversal point* enables an examiner to

determine the refractive status of his patient's eye, either by altering the distance of his view-point, or by changing the strength of lens "k" so the rays will focus, or cross, at any given point selected. The *difference* between the lens an eye *ought to take* to produce the shadow's action at a given point, and the lens it *actually does take*, constitutes the measurement of the error.

THE SHADOW'S ACTION. Just why the shadow behaves in the *with* and *against* manner here described can be seen by reference to Figs. 33 and 34.

In Fig. 33, if a single ray is followed from the point of the

FIG. 33.



WHY THE SHADOW MOVES "WITH" THE MIRROR.

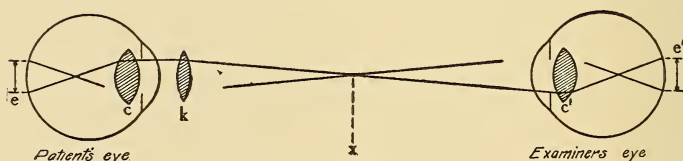
arrow, "e," on the *fundus* of the patient's eye, to "e'" on the *fundus* of the examiner's eye, the two arrows will be seen to point in the same downward direction. All motion can then be said to be *synchronous*, or coincident, as the *upper* emergent ray from the patient's eye becomes the *upper* entering ray of the examiner's eye.

In Fig. 34, owing to the refraction by lens "k," the *upper* emergent ray from the arrow's point "e" in the patient's eye becomes the *lower* entering ray of the examiner's eye, and the arrow "e" undergoes a reversal of position at "e'" by pointing upward. Motion can then be said to be opposite, or *against* the skiascopic movement of the facial light.

It is this motion of the shadow *with* and *against* the skiascope's movement that enables an examiner to locate the crossing "x" of the emergent rays, and the distance from the patient's eye at which this crossing occurs, together with the lenses necessary to cause it, constitute the means for determining the measurement of the error. Thus if a plus 1.50 D. lens, "k," is required to create a crossing of the rays at forty inches from an emmetropic eye, whose accommodation is relaxed, then the error would be plus 0.50 D., because plus 1. D. is the correct strength for a lens necessary to cause a crossing at this distance.

If a lens of only plus 0.25 D. caused a crossing of the rays at forty inches from the patient's eye, then the error would be

FIG. 34.



WHY THE SHADOW MOVES "AGAINST" THE MIRROR.

minus 0.75 D. And if twenty inches was the distance selected for the crossing, then plus 2. D. would be the working lens "k," from which calculations should be made, instead of plus 1. D.

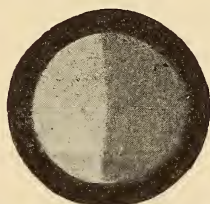
Skiametry has been ably described by Burnett as being controlled by the *law of conjugate foci*, therefore if an emmetropic or hyperopic eye is made *artificially myopic*, the strength of the lens required to produce this artificial *myopia* must enter into the final calculations. And if, on the other hand, the eye has *true myopia*, then the amount of the error can be easily determined by finding the crossing point of the emerging rays. Thus if the rays crossed at fifty-three inches from the patient's eye the error would be neutralized by a lens of minus 0.75 D. If

the crossing was at twenty-two inches distance, then the lenses needed would be minus 1.75 D.

THE SHADOW'S IMITATION. Fig. 35 will convey a slight idea of the appearance of a so-called "*shadow*" in passing across the pupil of an eye.

A much better illustration of this shadow phenomenon can be had by taking a piece of cardboard, say six inches square, and cutting a hole in it one inch in diameter, then by pasting over this aperture a piece of pink, translucent paper, and by holding the card before a lamp, a fair idea of the reddish appearance of the pupil of an eye when looked at through a skiascope may be

FIG. 35.



PUPILLARY APPEARANCE OF A SO-CALLED "SHADOW."

had. The edge of another piece of cardboard passed between the first card and the lamp will, by varying the distance, give a very good representation of the shadow as seen in an eye by means of a skiascope.

SHADOW MEASURING. All eyes must be measured in *two* or more meridians, so as to determine the greatest and least refraction. If these two are *vertical* and *horizontal*, and a plus 1. D. S. is placed before a patient's eye and the shadow is found to *reverse* at forty inches in the *horizontal* meridian, and at twenty inches in the *vertical*, then the error could be neutralized by a lens of minus 1. D. C. axis 180, but if it took plus 1. D. in the *vertical* and plus 2. D. in the *horizontal*, then

the lens required would be plus 1. D. C. axis 90. Or if it took plus 2. D. in the vertical and plus 3. D. in the horizontal, then plus 1. D. S. combined with plus 1. D. C. 90 would be the lens indicated.

It will be noted that 1. D. of *artificial myopia* was first created for the forty inches observation point, then in the final deductions this *created myopia* was allowed for.

If *true myopia* was present then no *artificial myopia* would be needed, unless the *true* was weaker, and had a point of crossing farther away than the point of *observation*. To illustrate this, suppose the *true myopia* was a half-diopter, the emergent rays would then cross at eighty inches, and if forty inches was selected as the point of *observation* the crossing of the rays would occur back of the examiner's skiascope, and the motion of the shadow would be *with* the mirror, the same as in *emmetropia* without lenses. In *emmetropia*, however, the placing of a plus 1. D. lens before the patient's eye would cause crossing at forty inches, but in a *true myopia* of a half-diopter the plus 1. D. lens serves to overdo the matter, therefore, a plus 0.50 D. would be the needed lens, or, if the *observation* was changed to twenty-six inches then the crossing could be found without changing the 1. D. lens. So the rule, before mentioned, that the *difference* between that which an eye *does* take and that which it *ought to* take, to cause reversal at a given point, represents the error of refraction in the meridian measured.

PRACTICE OF STATIC SKIOMETRY. In the practical application of *static* skiametry, a fifty-candle power light source should be situated at the patient's right, on a level with, and from six to twelve inches from, his ear. After placing a trial frame before the patient's eyes, two plus 4. D. S. lenses are to be inserted in each cell of the frame and the patient directed to look over the examiner's shoulder at some object placed twenty or more feet away, the examiner to be seated squarely

in front of the patient and operating his *plano* skiascope exactly forty inches from the patient's eyes. In *emmetropia*, under these conditions, the shadow will move *against* the mirror in all meridians, and the four diopters of lens power will have to be reduced to one diopter before reversal, or the neutralizing point of the emerging rays, occurs, the plus one-diopter lens being the so-called "working quantity" for an examination that is made at forty inches.

In *hypermetropia* of, say, one diopter the reduction of the four-diopter lens would be two diopters. And of these two diopters one diopter would represent the *error*, and the other the *working quantity* or *artificial myopia* necessary to create a *standard* condition, variations from which are to be measured by adding or subtracting lenses, or by altering the distances at which observations are made. This can be illustrated as follows: In a *true myopia* of, say, two diopters the movement of the shadow would still be *against* the mirror, even after the four-diopter lens had been removed, the examiner could then add *minus spheric* lenses, or he could advance his skiascope up to within twenty inches of the patient's eyes, as the emergent rays from the retina of an eye having two diopters of *true myopia* would have a conjugate focus at this distance.

Had the eye been myopic one diopter, the conjugate focus would have been exactly at forty inches without lenses of any kind, hence the rule in calculating all errors of refraction in *static* skiametry, where the working, or *observation*, distance is forty inches, is to add *one diopter of minus quantity* to the total findings, and this sum will then represent the error. Astigmia being truly a *half-spherical error* the examiner is to proceed as in simple *hypermetropia* or *myopia*, with the exception that the error is to be measured only in the meridian at right angles to the axis, and the *axis* is to be determined by noting the meridian in which there is no motion of the shadow when the *working lens* is in position.

Take as an example a patient with two diopters of *hyperopic astigmatism* in the *horizontal* meridian; if the examiner operates at forty inches with a plus one-diopter spherical lens before the patient's eye he will note a marked movement *with* the mirror in the *horizontal* meridian, but no movement in the *vertical*, this being the meridian of no error it is of course the *axis*. So, after noting this *axis*, by the general band-like appearance of the shadow, and that the *error* at right angles to this *axis* is *hyperopic*, all that remains for the examiner to do is to determine how great the *error* really is, and this is ascertained by adding *plus* lenses until *reversal* occurs.

Lenses used for neutralizing purposes can be either *spheric* or *cylindric*, for it will be remembered that two cylinders of equal strength and kind with their axes crossing one another at right angles are equal to a sphere. Therefore any astigmatism where the axis is *vertical* can be measured by the aid of a spheric lens used in its *horizontal* meridian, the *vertical* meridian being ignored. Where *cylindric* lenses are used great care must be exercised in placing the axis of the *cylinder* so it exactly coincides with the astigmatic axis of the eye, otherwise confusion of shadow-action and inaccuracies will occur.

So-called "*compound*" and "*mixed*" errors can be considered as being astigmatic in the two meridians of greatest and least refraction that are at right angles to each other. After a *working lens* is in position, suppose it takes a plus one-diopter to arrest the motion in the *vertical* meridian, and a plus two-diopter to do the same in the *horizontal*, then the case could be likened to a one-diopter *cylinder* being crossed by a two-diopter *cylinder*, which, if transposed, would resolve itself into the following formula: plus 1. D. S. combined with a plus 1. D. C. axis 90.

Looking at it another way, if the *vertical* meridian had taken a *minus* instead of a *plus* lens to neutralize its error the formula would then read minus 1. D. C. axis 180 crossed by a plus 2. D. C. axis 90, or transposed it would equal a minus 1. D. S.

combined with a plus 3. D. C. axis 90, so that all cases of *compound* and *mixed* errors are merely cases of *crossed cylinders*, and are capable of neutralization by either *spheric* or *cylindric* lenses.

THEORIES REGARDING DULL REFLEXES. In the consideration of a subject as broad as the term *ocular skiametry* would indicate, the temptation of an author to soar his kite in the realm of speculation and attach to its tail a few theories of his own is very great indeed, even if some of the theories should prove "bad pennies" and return to embarrass their giver.

In the actual practice of skiametry there arise certain little details which might be considered as *sub-phenomena*, and which exercise a more or less important bearing upon the system as a whole. Attention will therefore be invited to a few of these points which may perhaps savor more of *theory* than they do of *practice* but which, nevertheless, seem to answer natural questions likely to arise in the mind of those who desire to know the *why* of everything they are interested in.

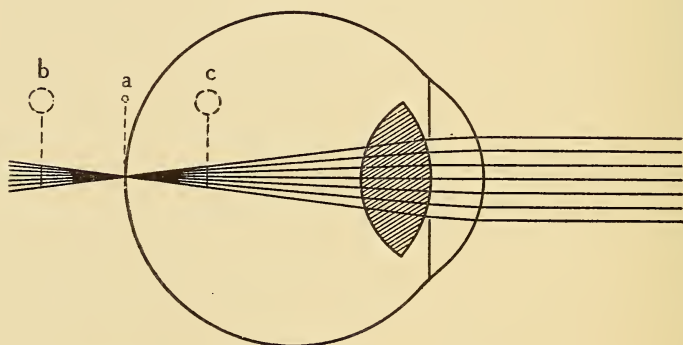
Ocular pupils of a size not exceeding two millimeters in diameter, notwithstanding an examiner's ability to magnify them, are often very troublesome and constitute a part of the cases which it is wise to determine by means other than by skiametry. This is especially true if, in addition to the smallness of the pupil, the *fundus reflex* is of the deeply pigmented or dull kind. The reason for this is due not so much to a failure on the part of the examiner to see the pupil as it is to the fact that the pupillary aperture prevents a sufficient volume of light from entering the eye in order to create a shadow sharp enough in outline to be readily measured.

In expecting to occasionally find some dull ocular *fundi* the examiner must not mistake high degrees of *myopia*, nor *hyperopia*, for excessive pigmentation. Especially in *myopia*,

even in an error of only four or six diopters, will the examiner sometimes be puzzled to determine why the *reflex* is so poor. Adding correcting glasses, however, often brightens this *reflex* in proportion as the correction nears the total, although at the exact reversal point of the shadow the *reflex* may again become very unsatisfactory, as may also the movements of the shadow at this time.

A *slow* motion must not be mistaken for *no motion*. For

FIG. 36.



WHY THE RETINAL ILLUMINATION IS LARGER IN AMETROPIA
THAN IN EMMETROPIA.

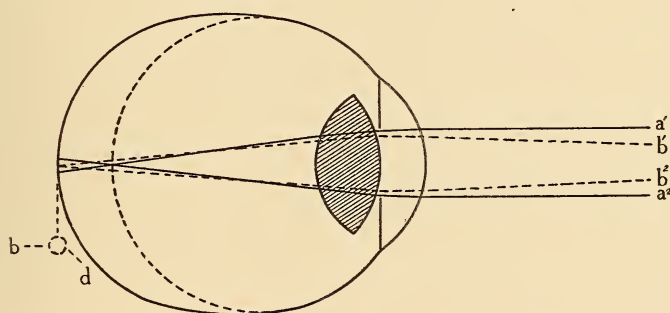
if Fig. 36 is looked at it will be seen why pronounced degrees of either *myopia* or *hyperopia* make large light areas on the retina, thus requiring a longer time for the shadow surrounding the light circles "b" and "c" to come into view than if these illuminated areas were smaller.

Fig. 37 also shows this principle emphasized in a *myopic* eye, the returning rays from the edge "d" of the illuminated area "b" illustrating the distance the shadow must traverse before reaching the opposite side, this area being much larger than

if the eye was an emmetropic one, where the proportion would be similar to "a" in Fig. 36.

The fact that a *reflex* in a given error of *myopia* is much duller than in a corresponding one of *hypermetropia* is due, no doubt, to the greater distance the returning rays travel in a *myopic* eye than in an *emmetropic* or *hyperopic* one before reaching the pupillary opening which, consequently, diminishes

FIG. 37.



WHY SHADOWS MOVE SLOWER IN AMETROPIA THAN IN EMMETROPIA.

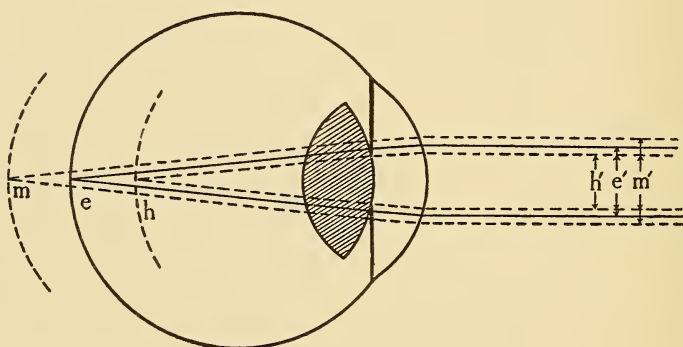
their number through radiation and absorption. Fig. 38 illustrates a theory for this. The lines "h' e' m'" show the relative loss by quenching as the divergent rays from a given illumination on the retina of a *myopic*, *emmetropic*, or *hyperopic* eye strike the inside of the *iris*, which serves to diaphragm part of them and prevent their further egress. The *hyperopic* eye, owing to its shorter depth, permits of the least interference with its radiation, but its retinal illumination, see "c" in Fig. 36, shows why its reflex is dull, though not as dull as that of the *myopic* eye "b," of Fig. 36.

Fig. 39 shows the comparative loss in intensity of illumina-

tion in eyes whose *myopic* or *hyperopic* error varies from one to sixteen diopters, "a" to "f" showing the relative size of the retinal area, illuminated, and thus accounting for the especially poor reflex in marked degrees of *myopia*.

Brightness of reflex, however, is not all there is to skiametry, for, owing to the optical phenomena called "*penumbra*," it is sometimes possible to obtain a more defined shadow under

FIG. 38.

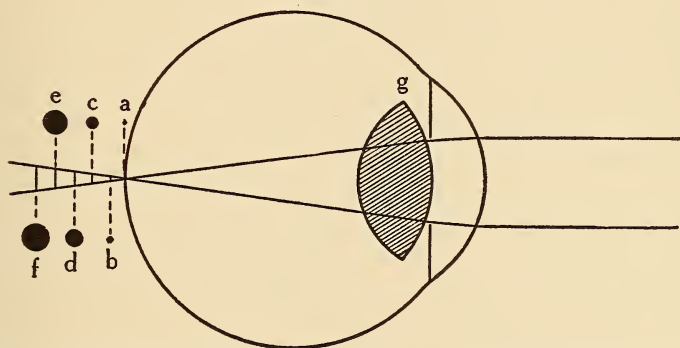


WHY A SHADOW IS DULLER IN MYOPIA THAN IN A LIKE DEGREE
OF HYPERMETROPIA.

a moderate illumination than it is under one more intense. A reason for this is suggested in Fig. 40. But just what part the numerous *penumbrae* play in interfering with the sharpness of demarcation of the shadow it is difficult to ascertain, for the emerging light casts its *penumbra* at the peep-hole of the examiner's mirror just as the entering light does at the pupil. And when it is considered that a round aperture is being dealt with it will be seen that the conditions are even more complex than would ordinarily manifest themselves if the shadow cast was a central one instead of being peripheral.

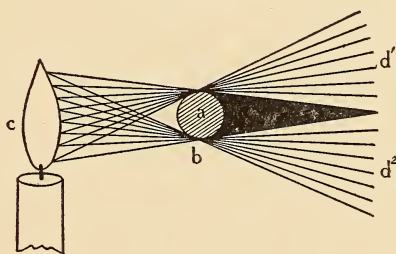
Figs. 40 and 41 may serve to make this subject better understood for, as has been said before, a sharp shadow is a great aid to good work.

FIG. 39.



RELATIVE SIZE OF RETINAL ILLUMINATION IN HIGH AND LOW DEGREES OF MYOPIA.

FIG. 40.



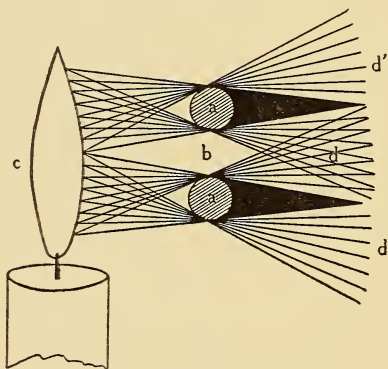
THE OPTICAL PRINCIPLES OF PENUMBRA.

In Fig. 41 the same principle can be seen as is shown in Fig. 40, only the conditions are doubled, for here there are three points on the candle flame instead of two, the central point acting in a manner which virtually makes it the same as though four points had been selected. The opaque object

"a" interferes with the passage of the horizontal rays of light from the candle "c." The oblique rays, however, pass at different angles and give rise to confused shadows as illustrated by "d¹" and "d²."

In Fig. 42 this principle has been adapted to an eye where *two* points of illumination are again shown whose source is located on the mirror-like *retina*, for it is only the center of the shadow that is involved, this shadow being produced by

FIG. 41.



THE OPTICAL PRINCIPLES OF PENUMBRA DOUBLED.

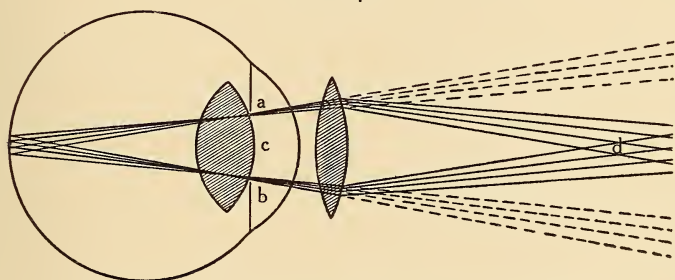
the iris acting as an opaque object. If either a *plus* or *minus* lens is placed in front of this eye it merely serves to *refract* all the light in accordance with the lens selected, the *penumbra* still remaining to add to the indistinctness of the edge of the shadow.

If this phenomenon could be overcome it would, seemingly, contribute much toward that skiametric accuracy for which all skiametrists are striving but, as heretofore shown, if a gain be made in one direction a loss is quite sure to follow in another, so that examiners must be content with fuzzy shadows until

some one solves the problem of how to get rid of them without interfering with the valuable points already secured in dealing with other conditions.

Operating at a distance, in order to produce parallelism of the rays, seems at present to be the only means of overcoming this phenomenon, but this, of course, bars out the use

FIG. 42.



INTERFERENCE OF PENUMBRA IN SHADOW TESTING.

of many tests and methods which have been found of great service in uncovering *ciliary* spasm and latent errors, etc. Thus it will be seen that many contributing factors toward both success and failure enter into the problem of accurately estimating the refraction of an eye "independent of a patient's intelligence."

CHAPTER V.

THEORY OF DYNAMIC SKIAMETRY, AND THE IMPORTANCE OF
RELIABLE FIXATION IN CO-ORDINATE AND INDEPENDENT
OBSERVATION, WITH A REFERENCE TO THREE ESSENTIAL
MYOPIAS, AND AN EXPLANATION OF "RAY VALUES."

THEORY OF DYNAMIC SKIAMETRY. The optics of *dynamic skiametry* can be considered as being the same as the optics of *static skiametry*, one being fixation *within* infinity while the other is fixation *at* infinity.

The word "*dynamic*" is derived from the Greek word *dynamis*, and signifies forces not in equilibrium, or motion as the result of force, being the opposite of "*static*."

Dynamic skiametry then, as might be readily inferred, is an application of Bowman's discovery made under some kind of force. This force is the muscular one which is familiarly known as *accommodation*.

While the *static* method of practising skiametry is one where the *ciliary* muscle of an eye is at rest, the *dynamic* method is the exact reverse of this, and is made while the *accommodation* is exerting itself sufficiently to readily accept refractive assistance up to a point where its relation with another muscular force called "*convergence*" is interfered with.

The principle involved is a simple one. It is well known that a pound weight placed upon the shoulder of a sturdy man creates no appreciable burden or discomfort. But load this same man down to almost the limit of his endurance and then add this pound of additional weight and its presence will be noticed at once. So it is in *dynamic* skiametry, a call is made for a pronounced increase in tension of the *accommodation*

by having the patient read a series of test letters placed either on an examiner's brow, attached to his skiascope, or to a fixation stand, then, by varying this tension as judgment teaches and by being able to easily supply required artificial lens power, the *accommodation* is reduced to its normal relationship with *convergence*. And most eyes, no matter what the age of the patient may be, will only surrender the accommodative *excess* which has been required to maintain near-vision. This *excess* will therefore be composed of what has formerly been called by the name of "*spasm*," or "*latent*" hypermetropia.

The relationship between *accommodation* and *convergence*, if roughly stated, is found to be in about the proportion of *one to three* for the two eyes; that is, when the *accommodation* is exerted to the extent of one diopter, the *convergence* required, according to Hartridge, is a little over one and one-half degrees for each eye. This, of course, is subject to variation, for when the *accommodation* equals ten diopters the *convergence* is estimated to be slightly over eighteen degrees for each eye.

Another way of viewing this is to consider that for every diopter of *accommodation* exerted there is a corresponding *meter angle of convergence* called for, and a *meter angle* is described as the angle created by an imaginary line drawn from an eye to a point forty inches away, where it crosses another line called the "*median*," which is drawn from midway between the two eyes. Two *meter angles* converging at twenty inches away would then be in harmony with two diopters of *accommodation*, and so on. To prove that the relationship between the two factors governing ocular adjustment is reliable, and that eyes *under normal conditions* do not *converge* without *accommodating*, nor *accommodate* without *converging*, the following simple experiment can be made: Take a person under forty years of age with known *emmetropia* and place him so that his eyes are exactly forty inches away from the smallest

test type which he can see to read at this distance, then while he is engaged in the act of reading add a half-diopter convex lens quantity to both eyes, and it will be noted that the print will be perceptibly blurred or dimmed. In making this experiment be absolutely sure that there is no *latent* error present, or the test will prove unreliable.

Now this seems to show that the relationship between these two forces is a quantity adjusted finely enough to be relied upon, for without the control of the *convergence* the *accommodation* would have immediately relaxed when the lens was added which took away the necessity for the amount of muscular exertion represented by the fraction of one diopter which the lens called for.

An understanding of this point is very essential, as it represents the basic principle upon which the *dynamic* method is founded. It is well known that both *accommodation* and *convergence* are elastic quantities, as an *emmetrope* with normal *accommodation* can wear minus lenses up to the limit of his *amplitude* without producing *diplopia*, also that the adduction and abduction of *orthophoric* eyes run into large figures before the doubling of an object occurs. Hence it will be seen that the relationship between these two forces is liable to vary in accordance with the training received by the muscles controlling them. And these, in turn, by the innervation of the nerves that transmit the vitalizing impulses.

Two elastic bands linked together, in which the strength of one may be double that of the other, will find a point of *balance*, or equality of resistance, if stretched to any degree whatsoever, therefore when it is borne in mind that *accommodation* and *convergence* always have an *individual balance* for every visual point for which they co-operate it can be understood why *fixed* rules for adapting prisms must prove unreliable.

A case in point may emphasize this: A person born with two diopters of *hypermetropia* is compelled to suppress six

degrees of *convergence* while looking at a distance, this becomes a sort of habit which, owing to the greater development of the ciliary muscles through more than ordinary use, requires a new standard of relationship to be maintained that is adapted to this special condition.

It might be reasoned that there are two ways of correcting such a case as this, one by relieving the tension on the *intrinsic* muscles with *lenses*, and the other by adapting *prisms* for the aid of the *extrinsic ones*. In some cases perhaps both forms of relief are indicated, but in most cases the wise procedure is to correct the refractive defect and then, by time and development, train the weakened *extrinsic* muscles up to an approximate standard of "1 to 3" relationship with the *intrinsic* ones.

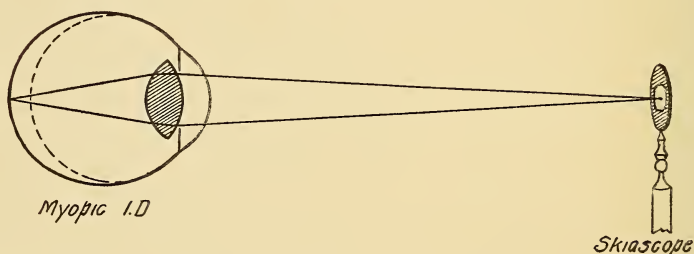
Most eyes have some kind of a refractive error, or else they are so placed in the head that their relative position as to pupillary distance is at fault, and for this reason there is a sort of *individual equation* in almost every case which calls for special judgment. And it is this *individuality* that causes one patient to fix upon sixteen inches as a comfortable reading point, while another person, of the same age, will select a twelve-inch point.

It has been stated that *accommodation* is *captain* of the visual ship, but captains have other persons to boss them, the same as fleas are said to have "other fleas to bite them," etc. So *convergence* might be called *first mate*, as its influence is undoubtedly felt in the compromise that must occur for all binocular visual fixation points. If this was not the case then *emmetropes* would read with comfort with *spheric* lenses of plus three diopters at thirteen inches, no matter how young or old the person was. The facts are, however, that an *emmetrope* with abundant *amplitude of accommodation* resents even a quarter of a diopter of artificial lens aid when reading at any near point, and the reason therefor is because the natural *locking point*, if it can be called such, between

accommodation and *convergence* has been interfered with. This natural locking point, or relationship, constitutes the foundation upon which *dynamic skiametry* rests, and it can be relied upon to automatically adjust itself to the proper refractive quantity for any given distance—habit, general health and muscle innervation considered.

In the optical principles of *static skiametry*, as given in the previous chapter, it was required that the rays of light emanating from the *retina* of a patient's eye have a *conjugate focus* or, in other words, that *true* or *false* myopia be present in

FIG. 43.



TRUE MYOPIA (STATIC METHOD).

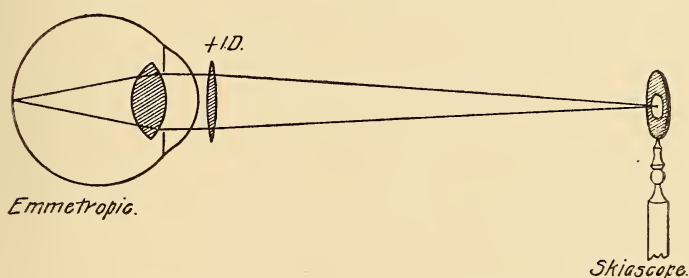
order to measure it, and thus to secure data upon which other calculations can be based. Fig. 43 shows an eye with *true* myopia of one diopter, hence emerging rays of light come to a natural focus forty inches away.

False myopia can be of two kinds, *artificial* and *accommodative*. *Artificial myopia* is produced by using a plus *spheric* trial lens, and *accommodative myopia* is temporarily acquired by having the patient look at a *fixation object*.

By the *static* method it is required that a one-diopter trial lens be employed when the working distance is forty inches away, so that *artificial myopia* may be produced and the

emerging rays from an eye made to focus, or cross one another, at the focal length of the lens used. This is correct for this method, but for the *dynamic* method no trial lens is required to produce this *false myopia*, as the *crystalline lens* of the eye under examination takes its place. Fig. 44 will perhaps make this plainer, for in the drawing the *false myopia* under the *static* method is created by means of a trial lens, the eye being *emmetropic* and the rays emerging parallel before being refracted by the plus 1. D. trial lens.

FIG. 44.



ARTIFICIAL MYOPIA (STATIC METHOD).

Under the *dynamic* method, Fig. 45, the *false myopia* is created by means of an increase in the convexity of the *crystalline lens*, better known by the term *accommodation*, or "*punctum accommodatum*," as Burnett calls it, the vision being *fixed* on some nearby object.

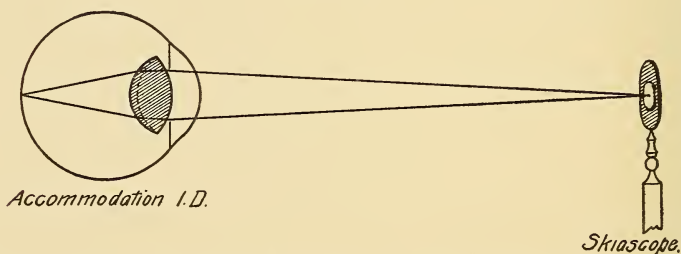
This eye, the same as in Fig. 44, is *emmetropic*, thus making the two working conditions practically equal.

By the *static* method, if the test is to be made at ten inches, a four-diopter convex lens must be used. By the *dynamic* method this four-diopter convex lens power can virtually be added to the *crystalline lens* of the eye under examination by advancing the fixation card of the examiner up to a distance

of ten inches from the eyes of the patient, thereby causing the *accommodation* to be exerted to this degree in order that the letters on the card may be distinctly read; this effort, or the result of it, is why it is termed *accommodative myopia*, as distinguished from the *lenticular* or *artificial* kind produced by the trial lens.

To illustrate the value of this method, and also to show its practical adaptation, a case will be considered whose error of refraction is two diopters of *hypermetropia*, one diopter of which is *manifest*, and one diopter *latent*, or in a condition

FIG. 45.



ACCOMMODATIVE MYOPIA (DYNAMIC METHOD).

somewhat spasmodic. In examining this eye at a distance of forty inches, the patient looking at some object twenty or more feet away, it is found that the *static* method shows one diopter of *hyperopia*, as it takes a two-diopter convex lens to produce a reversal of the shadow at this distance, one diopter of which represents the *artificial myopia*, or the working refraction required. The *dynamic* method being used in this case, it is discovered that when the patient looks at the fixation card, forty inches away, a convex lens of a diopter and a half can be added before a reversal of the shadow is obtained, the examiner then advances so as to make the test at a distance of thirteen inches and finds that two diopters can be added before reversal takes

place. Advancing to within ten inches of the patient's eyes makes no change. Withdrawing to forty inches again, it is found that very little alteration in appearance of the shadow has occurred unless the patient has looked away in the meantime, when the *spasm* will most likely reassert itself.

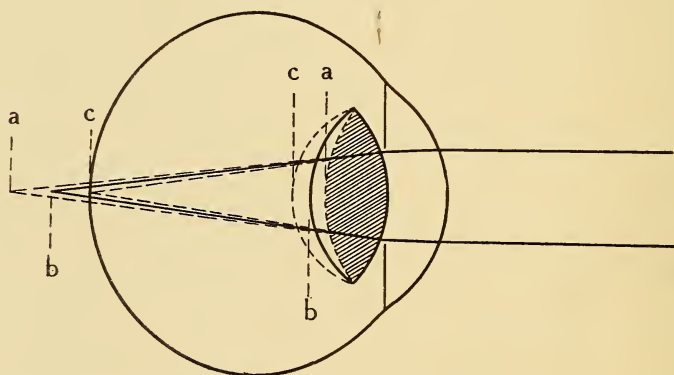
Now what has taken place? The *accommodation* called for by the *dynamic* method at forty inches was one diopter. The patient having two diopters of *hypermetropia* had, therefore, to make a total *accommodative* effort of three diopters, in order to see the letters on the fixation card. The examiner supplies refractive assistance until one diopter and a half of convex lens quantity has been added, the *accommodation* relaxing to this degree and the shadow showing a reverse movement. Perhaps this case is one where the age of the patient is less than twenty years, general health considered good, and muscle tension, or unconscious habit of exertion, is suspected of being vigorous. A new test is made at a distance of thirteen inches where the total *accommodation* called for is five diopters, of which two represent the *hyperopia* and three the amount called for in *emmetropia* at this distance. Under this burden the eye will be found to accept a two-diopter convex lens quantity before reversal occurs. Repeating the test again at ten inches no more relaxation is found, thereby proving the second finding to be correct.

To analyze still further, it may be stated that at thirteen inches, where an *emmetrope* uses three diopters of *accommodation*, nine degrees of *convergence* are called for. A patient, therefore, who is making five diopters of *accommodative* effort, ought, correspondingly, to make fifteen degrees of *convergence*, thus calling for a distance of eight inches.

So, as before stated, while both *accommodation* and *convergence* seem somewhat elastic they, nevertheless, appear to have a tendency to attain a standard co-ordination when disturbing factors are removed.

Fig. 46 is intended to illustrate the mechanical action of a *spasm of accommodation* equal to a half-diopter. The line "a" shows the position of the lens when the *accommodation* is at rest. The line "b" shows its position when the *accommodation* is equal to a half-diopter of involuntary effort, called "*spasm*," and the dotted line "c" shows when the *accommodation* is equal to one diopter.

FIG. 46.



HOW THE ACCOMMODATION CAN ABSORB A CILIARY SPASM.

If the *spasm*, or *unconscious* muscle effort, equals a half-diopter, and the patient be required to look at an object which calls for one diopter of *accommodation*, then the *conscious* effort will, of course, be equal to the difference, or one half-diopter more. It can thus be seen that a *spasm* may be gotten rid of by what might be fittingly termed *absorption*.

In applying this method to cases where the *spasm* is likely to be greater than one diopter, such as in children, or in those cases when heterophoria is present, the test should be made at a shorter distance than forty inches. Twenty inches, for instance, calling for two diopters of *accommodation*, ten inches for four diopters, and so on.

Another view for the elimination of *spasm* by the *dynamic* method can be taken: A man is told that he owes one dollar which he is desired to pay. He consults his books and finds that he has already paid fifty cents of this amount. Then all that can be righteously collected of him is the difference, or the remaining fifty cents. Now this same man consults an optometrist, and is required to exert his accommodation equal to one diopter, but having a *spasm* of a half-diopter—and *ocular spasms*, as it is known, are really unconscious muscular efforts—he has, therefore, unknowingly contributed a half-diopter of *accommodation* which constitutes one-half of the amount requested of him, so he thus needs to *consciously* add a half-diopter more and the request is fully complied with. If his obligation, or error, had been higher the request would have had to be greater, but the principle is the same, and so when it comes to actual tests made by this method it will be found that the theories here expounded will be borne out in practice.

Spasms of accommodation are now generally classified under two heads—the *tonic*, or persistent muscle effort, which is often called *latent hypermetropia*, and the *clonic*, or intermittent action of the ciliary, which is frequently met with in the objective estimation of both *hypermetropia* and *myopia*, particularly the latter. Both kinds, however, are factors in ocular skiometry of which cognizance must be taken and methods used whereby their disturbing influence can be overcome.

It is a rule that in persons over forty years of age, skiometric findings made by the *static* method are fairly reliable, but the drawback to the universal use of this one method lies in the inability of an examiner to differentiate his cases and to tell in advance whether he is dealing with a case wherein *spasm of accommodation* is a factor until after he has used the *dynamic* method and compared results. Therefore, to save time and avoid error, it is wise for an operator to use the *dynamic* method

in all cases under fifty years of age; and where the patient is under thirty it is best to use this method at as close a point as from ten to thirteen inches away.

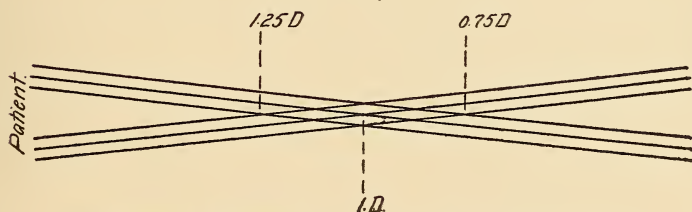
RELIABLE FIXATION. This subject, which has a direct bearing upon the question of brightness of the *fundus reflex* and corresponding definition of the pupillary shadow, relates to the visual angle under which examinations should be made, also to the point at which the patient's accommodation is to be adjusted during the observations. The point of reversal of a shadow is a very difficult one to decide upon with any great degree of exactness, for the reason that at the precise crossing point of the returning rays the shadow is most erratic and very difficult of determination as to its action. And as no lens power can be added to or subtracted from a patient's *accommodation* without interference with this action, it will readily be seen that the examiner's mirror must be operated either *inside* or *outside* of a patient's exact point of *fixation* if the behavior of the shadow is to be accentuated.

In other words, if a patient is looking at a point exactly fifty-three inches away, and an examiner makes his *observation* from a point forty inches distant, the shadow will show a *hyperopic* movement equal to a quarter of a diopter. On the other hand, if the examiner views this same eye from this same distance of forty inches, the patient, however, being required to look at a card situated thirty-two inches away, the shadow's action will be a *myopic* one of a quarter of a diopter. Fig. 47 will perhaps make this plainer, for here it will be seen that the adjustment of the patient's accommodation was first made for a distance equal to three-quarters of a diopter, and then for a distance equal to a diopter and a quarter, the observer being at a distance of one diopter in both cases, the action of the shadow was, therefore, first *with* the mirror and then *against* it, whereas if a test had been made at one diopter the shadow,

of course, would not have shown any motion. Thus it will be seen that the method is not unlike solving the question of the exact middle of a piece of string by simply doubling it, for this is what it practically amounts to.

In estimating the behavior of the shadow the advantage gained by an examiner in making his estimate from two or three focal adjustments of his patient's *accommodation* is, of course, just double or treble that of making it from a single point. Besides, it frequently occurs that an examiner desires to approximately ascertain the amount of any *myopia* present before he changes his lenses. All he has to do, then, is to

FIG. 47.



MULTIPLE FIXATION AND OBSERVATION POINTS.

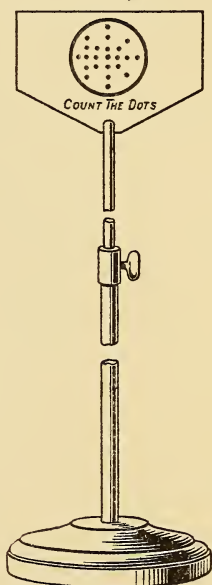
advance his mirror nearer to his patient while the latter is still looking at the forty-inch *fixation* point. If he finds that the shadow does not reverse until the mirror is advanced to within twenty inches of the eye under examination, then he knows that the *myopia* present is about two diopters, one of which represents the *error* and the other the *accommodation*. And if he has to advance up to within ten inches before obtaining a *reversal* he then knows that the error is nearer to three diopters, and so on.

The means for accomplishing these results are very simple indeed. Fig. 48 shows a *fixation* stand, and the manner of its construction which, as can be seen, is merely a light-weight nickel-plated brass stand carrying a card having dots upon it

which the patient is asked to count. The stand being movable, and adjustable as to height, permits of its usefulness in many ways.

Fig. 49 shows the style of card this stand can carry, on the reverse side of which is printed a small astigmatic dial, Fig.

FIG. 48.



AUTHOR'S FIXATION STAND.

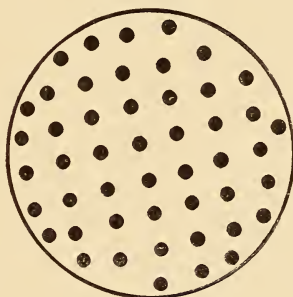
50, which is merely a convenience to be used in other tests not concerned with skiametry. This stand, however, can be made to do excellent duty as a *dynamic astigmometer*, enabling *subjective* measurements to be taken at any near point desired.

INITIAL EXAMINATIONS. In initial skiametric tests the card, Fig. 49, is usually placed about a foot behind an examiner's head, several inches to his right, and high enough for

its dots to be illuminated by the light source used, Fig. 51, showing the relative position of light, examiner, patient and fixation card.

In operation the examiner requests his patient to first look at the dots on the *fixation card*, fifty-three inches away. In

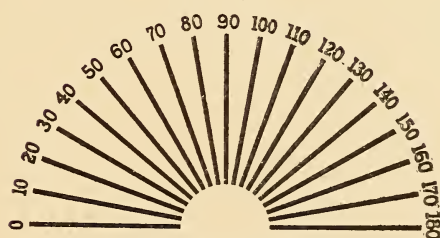
FIG. 49.



Count the Dots.

FIXATION-STAND TARGET CARD.

FIG. 50.



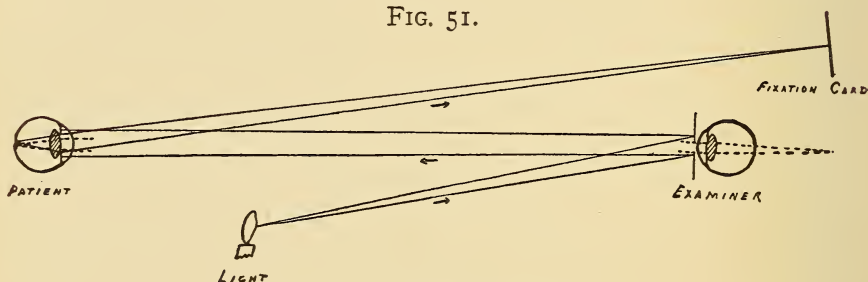
REVERSE SIDE OF FIXATION CARD.

making his lens changes he stops with the shadow moving slightly *with* the mirror, then he requests the patient to look at *fixation target cards* on his skiascope. If he gets a *reversal* of the shadow he knows that he is very close to a correction for this distance. He then proceeds to finish the test and eliminate

the presence of any *ciliary spasm* by moving the mirror and its targets nearer to the patient, and at the same time crowding on all the convex lens quantity possible without producing an against motion.

The card on the fixation stand may be used in place of the *skiascope card* for the shorter focal tests, but it will not be found as convenient. The greatest advantage to be derived from the employment of the fixation stand, however, lies in the angle at which an eye can be viewed, also in the apparent brilliancy and enlargement of the patient's pupil, which is due, no doubt, to a

FIG. 51.



POSITION FOR INITIAL EXAMINATION.

corresponding decrease in light stimulation. But, be that as it may, the use of the fixation stand in most cases is productive of much better initial results than accrue when its use is dispensed with. Especially is this true where the examiner is somewhat lacking in the experience which comes only with years of practice.

The system of multiple cards, or *fixation points*, has an added value to an examiner from the fact that it enables him to make the first observation of a patient's eye under the most favorable conditions possible for obtaining a bright *fundus reflex*. He can then govern himself accordingly in further examination of the case.

If the *reflex* is a bright one, the change of vision from stand to skiascope card will not materially affect its brilliancy. On the other hand, if the *reflex* is poor then further tests should be continued by aid of the stand, which, being light in weight, its position can be easily altered by the examiner.

There is another very valuable feature connected with the use of independent *fixation* points, and that is in the estimation of weak errors of refraction by instructing a patient to look back and forth from *skiascope* to fixation stand while the distance of these two from the patient's eye differs slightly.

RAY VALUES. The term "ray" is used in preference to the term "wave," simply for purposes of easy explanation and ready comprehension; therefore, from the foregoing, it will be understood how important it is for an examiner to have a thorough knowledge of *ray values* as well as of *lens values*. And by "*ray values*" is meant the strength of the lens that would be required to parallel a ray of light when intercepted at any distance from its source. Fig. 2 in the first chapter emphasizes this principle. The value of a *ray* ten inches from its *source* is 4. D.; at thirteen inches, 3. D.; at sixteen inches, 2.50 D.; at twenty inches, 2. D.; at twenty-six inches, 1.50 D.; at forty inches, 1. D., and so on.

In using both *static* and *dynamic* skiametry the position of an examiner and the dioptric values of his lenses in their relation to his patient's visual fixation are all factors in the correct estimation of ocular errors. Thus, if a patient is looking at an object situated eighty inches distant, and a skiametric examination is made at forty inches away, the *ray value* at eighty inches may be said to equal a half-diopter, while its value at forty inches is one diopter; one less a half leaves a half, and the shadow under these conditions will behave as though the error were a half-diopter of *hypermetropia*.

If the patient was looking at an object forty inches away,

and the examiner viewed the eye through the *skiascope* at a distance of eighty inches, then the reverse would of course be the case, and the error indicated would be a half-diopter of *myopia*.

All of this, however, presupposes that the examiner knows just what his patient's *accommodation* is doing, and so by having *fixation* cards situated at forty, fifty-three, eighty, one hundred and sixty, and three hundred and twenty inches away, respectively, it would be possible for an examiner working at one meter to observe the shadow's action in the four quarters of a diopter of *hypermetropia*. This would necessitate the securing of an especially intelligent and obedient patient, together with expert skill on the part of an examiner.

Later on it will be seen that other methods can be used, where the intelligence of the patient is not so important a factor. The same principle governing *ray values*, however, can be applied to shorter distances. Thus, a patient with a one-diopter convex trial lens before his eye, when looking at a *fixation* card forty inches away, can be measured for a quarter, a half, or three-quarters of a diopter of *hypermetropia*, if the examiner will carefully measure the distances from his patient's eye so as to hold his mirror exactly thirty-two inches away when he is measuring for three-quarters of a diopter, twenty-six inches away when he is measuring for a half, twenty-two inches away when he is measuring for a quarter, and so on, the *ray value* modifying the *lens value* and the two combined influencing the total. In fact, in skiametry the determination of *ray values* can perhaps be summed up by deducting the value of what the ray is *actually* doing from what it really *ought* to do under the circumstances.

The possibilities in the way of juggling with *accommodation*, *lens values*, *ray values* and the *shadow*, are almost limitless, and it is to be expected that as *ocular skiametry* and its methods become better known there will be found many more

ways of applying its principles which may not be all fully understood at this time. As the student acquaints himself with the principles involved in *ray* and *lens* values, however, he will find that the practical side of his work can be made much easier. The following examples, too, may show the application of some of the more important points: When an eye looks at an object situated forty inches away it must exert its *accommodation* at least one diopter. Place a plus one-diopter *spherical* lens over this eye and if it is *emmetropic* the *emergent* rays will *converge* at a point twenty inches away. One diopter will then represent the *accommodation*, and one diopter the trial lens, or *artificial myopia*, making a total of two. If a plus two-diopter lens is used, the point of *convergence* will be at thirteen inches; if a plus three-diopter is employed, it will be at ten inches; the *accommodative myopia* increasing the *total myopia*.

Now suppose a patient has an error of two diopters of *hypermetropia*, then what occurs when a three-diopter lens is added? Why, the *accommodation* under the stress of carrying a burden immediately surrenders its error, readjusts its *accommodation* and *convergence* to a relationship of least resistance, and there is left only one diopter of what we call *artificial myopia*, and one of *accommodative myopia*. The point of *convergence* of the *emergent* rays would then be at twenty inches, instead of at ten inches, which would be the point of crossing of the rays from an *emmetropic* eye under the same conditions of *lens* and *accommodation*. Therefore it will be seen that where the rays *ought to cross* is at ten inches, and where they *do cross* is at twenty. The difference in *ray value* being two diopters—the amount of the error.

In cases of this kind it is only natural for a student to ask why an eye under these conditions does not surrender *more* than two diopters, especially when it is exerting its *accommodation* one diopter for *fixation*. In reply it can be said that, without compulsion, an eye which is making three degrees of

convergence will naturally try to make one diopter of *accommodation* in order to maintain the harmony of the theoretic standard of *one to three* relationship. This explanation can also be given to account for the discomfort an *emmetrope* of, say, twenty years of age, experiences when attempting to read at thirteen inches distance with a pair of half-diopter plus *spheric* lenses on, his *accommodation* and *convergence* will not be in accord. The *convergence* required at thirteen inches is nine degrees, which calls for a co-ordination of three diopters of *accommodation*, but try to reduce this *accommodation* by even a quarter-diopter and the harmony will be disturbed, causing discomfort to manifest itself.

In *true myopia*, of one diopter, similar conditions of *ray* and *fixation* values are present, one diopter for *accommodation* at forty inches, and one for the *true myopia*, make two, the *ray value* of which is twenty inches. In all pronounced errors of refraction an examiner must ever bear in mind that the relationship of *one to three* between *accommodation* and *convergence* may have been upset, and a different co-ordination established. Measurements in *myopic* cases frequently vary under *ray* and *lens* value procedure, but while *skiametry* always gives the refraction exactly as it is under the existing conditions, these conditions may be such as to trouble an examiner in the formation of his judgment. Hence measurements taken in different ways are productive of better results.

In measuring cases by *ray values* a student can work out any combination if he is well grounded in these principles. *Simple*, *compound* or *mixed* cases of *astigmia* are merely to be solved by measurement of meridians, as for instance: An eye having one diopter of *hyperopic astigmia*, axis *vertical*, in fixing at forty inches with a plus one-diopter *spheric* lens before it would show reversal of the shadow in the *horizontal* meridian at forty inches, and at twenty in the *vertical*.

In a *myopic eye* represented by the correcting formula of minus 1. D. S. combined with minus 1. D. C. axis 180 and fixing at, say, twenty inches, reversal would occur in the *vertical* meridian at *ten* inches and in the horizontal at *thirteen*. The student can therefore see that the whole subject is practically one of figures, where *axis* and *error* are always to be considered as at *right angles* to one another, and that *myopia* may be classified as of three kinds : *true*, *accommodative* and *artificial*.

CHAPTER VI.

ORTHOPHORIC AND HETEROPHORIC CONDITIONS, AND THE INFLUENCE OF HABIT UPON ACCOMMODATION AND CONVERGENCE, WITH SPECIAL CONSIDERATION OF SPASMS AND THE USE OF PRISMS.

ORTHOPHORIA AND HETEROPHORIA. In order to again emphasize the strong points of *dynamic skiametry* it will be wise to further consider ocular muscle action and note its relation to other factors that are involved in the production of binocular vision, both with and without so-called *strain*.

The perfect balance of the *extrinsic* muscles, termed *orthophoria*, is a rare condition, because with *orthophoria* there must, theoretically, be *emmetropia*, and experienced examiners know that scarcely one eye in a hundred is truly *emmetropic*. Therefore the concomitant of *ametropia*, as will be seen later on, is *heterophoria*, for, owing to the distribution of the ocular nerves, a single impulse would seem to affect both the *intrinsic* and *extrinsic* muscles in a co-ordinate manner, unless unconscious *habits* have been formed whereby one muscle action can be suppressed while another is exerted, even though the nerve supply is the same. Now this involves the question: What is a muscle and why does it act? So, without making the subject too lengthy, the dictionary may be briefly quoted as stating that *a muscle is an organ composed of contractile fibres, through the contraction of which bodily movement is effected*. These muscles are classified as *voluntary*, *involuntary* and *mixed*, the *voluntary* being subject to the will, the *involuntary* acting independent of the will, and the *mixed* combining in some degree the functions of both the others.

All muscles are made to contract by means of nerves, and a nerve is described as *a cord-like structure composed of delicate filaments through which sensations, or stimulation impulses, are transmitted to and from the brain*. These impulses being an expression of what is called *nervous energy*, which represents the active principle of organic life, this nerve action being dependent for its existence upon warmth, food and the orderly performance of the functions of the body. It will be seen, then, that this question is much like the ancient's description of wisdom, which was represented as a serpent with its tail in its mouth, for the reasoning resembles a circle, no beginning or ending, since the nervous energy seems to reproduce itself. In other words, it takes *health* to make *nervous energy*, and *nervous energy* to make *health*.

INFLUENCE OF HABIT. As before referred to, ocular habits of adjustment are factors to be reckoned with in the adaptation of glasses, for it is not difficult to understand that if an eye has been exerting its *accommodation* for many years in overcoming an error, like *hypermetropia*, the *convergence* has had to form special habits, too, in order to harmonize with the *accommodation*. Then when glasses are given for the correction of the *hypermetropia* it follows that *convergence* must be re-educated and adapted to the new relationship.

Prof. William James says that "habit has a physical basis" and, that "the moment that one tries to define what habit is, one is led to the fundamental properties of matter." He further says that the phenomena of habit in living beings are due to the plasticity of the organic materials of which their bodies are composed, and that the philosophy of habit at bottom is a physical principle and therefore belongs to physics rather than to physiology or psychology.

Léon Dumont says: "Every one knows how a garment, after having been worn a certain time, clings to the shape of

the body better than when it was new, and so in the nervous system the impressions fashion for themselves appropriate brain paths."

Muscle habits are really brain habits, and of habits in general Professor James can be quoted still further, he says: "Habit is what keeps us all within the bounds of ordinance, and saves the children of fortune from the envious uprisings of the poor. It alone prevents the hardest and most repulsive walks of life from being deserted by those brought up to tread therein. It keeps the fisherman and the deck-hand at sea through the winter; it holds the miner in his darkness, and nails the countryman to his log-cabin and his lonely farm through all the months of snow; it protects us from invasion by the natives of the desert and the frozen zone. It dooms us all to fight out the battle of life upon the lines of our nurture or our early choice, and to make the best of a pursuit that disagrees, because there is no other for which we are fitted, and it is too late to begin again. It keeps different social strata from mixing. Already at the age of twenty-five you see the professional mannerism settling down on the young commercial traveler, on the young doctor, on the young minister, on the young counsellor-at-law. You see the little lines of cleavage running through the character, the tricks of thought, the prejudices, the ways of the 'shop,' in a word, from which the man can by-and-by no more escape than his coat sleeve can suddenly fall into a new set of folds. On the whole, it is best he should not escape. It is well for the world that in most of us, by the age of thirty, the character has set like plaster, and will never soften again.

"If the period between twenty and thirty is the critical one in the formation of intellectual and professional habits, the period below twenty is more important still for the fixing of personal habits, properly so called, such as vocalization and pronunciation, gesture, motion, and address. Hardly ever is a language learned after twenty spoken without a foreign accent; hardly

ever can a youth transferred to the society of his betters unlearn the nasality and other vices of speech bred in him by the associations of his growing years. Hardly ever, indeed, no matter how much money there be in his pocket, can he even learn to dress like a gentleman-born. The merchants offer their wares as eagerly to him as to the veriest 'swell,' but he simply cannot buy the right things. An invisible law, as strong as gravitation, keeps him within his orbit, arrayed this year as he was the last; and how his better-clad acquaintances contrive to get the things they wear will be for him a mystery till his dying day.

"The great thing, then, in all education, is to make our nervous system our ally instead of our enemy. It is to fund and capitalize our acquisitions, and live at ease upon the interest of the fund. For this we must make automatic and habitual, as early as possible, as many useful actions as we can, and guard against the growing into ways that are likely to be disadvantageous to us, as we should guard against the plague. The more of the details of our daily life we can hand over to the effortless custody of automatism, the more our higher powers of mind will be set free for their own proper work."

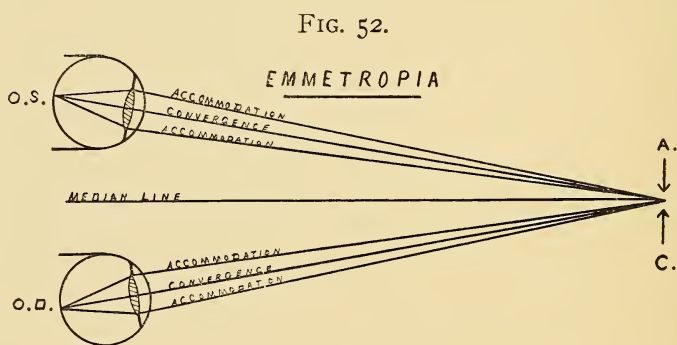
The influence of habit upon our ocular functions is very strong indeed, as in most cases we are able through muscular effort to adapt ourselves to our visual necessities, even though we unconsciously pay a price in what is called "nervous strain." A *hypermetrope* in accommodating for his error is not unlike a man in walking with his feet turned outward at too great an angle, for, while both are possible for a period to time, yet continued effort will eventually be productive of bad results. Habits of seeing under proper refractive and muscular adjustments should be acquired by all at as early an age as will prove practicable for a person to wear glasses.

Figs. 52, 54 and 56 are designed to diagrammatically illustrate the relationship between *accommodation* and *convergence*

in *emmetropia*, *hypermetropia* and *myopia*, while Figs. 53, 55 and 57 may give some idea of the nervous adjustment required to meet the ocular needs, from the standpoint of *innervation* and *enervation*.

Fig. 52 is intended to show, by means of converging lines, the normal balance in an *emmetropic* eye between the muscles governing *accommodation* and those controlling *convergence*.

Here it will be seen that the harmony between these two factors necessary to binocular vision is in accord, and that the



BALANCING THE ACCOMMODATION AND CONVERGENCE IN
EMMETROPIA.

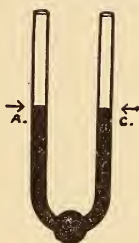
lines representing *accommodation* and *convergence* meet at a common point on another imaginary line called the *median*, which extends forward from midway between the two eyes, the *innervation* of course being directed toward the *internal rectus* and the *ciliary* muscles of each eye.

Fig. 53 is designed to show a pair of thermometer-like tubes which, for convenience, might be styled a *neurometer*, these tubes being filled with an imaginary vital fluid representing the nervous energy required to maintain the action of *accommodation* and *convergence*. The darts are to call atten-

tion to the height of the fluid in the two columns, and to show the relative amount of nervous expenditure necessary to maintain requisite muscle effort. Thus in *emmetropia* the darts seem to be equal and indicate that whatever the proportionate relationship really is, it remains a quantity that can be considered as constant.

In Fig. 54 may be seen the disturbed relation between *accommodation* and *convergence* which would take place in *hypermetropia* if the innervation was normal, as shown in Fig.

FIG. 53.



EQUAL INNERVATION NECESSARY TO BALANCE ACCOMMODATION
AND CONVERGENCE IN EMMETROPIA.

53. Thus *esophoria* and the origin of *convergent strabismus* can be surmised.

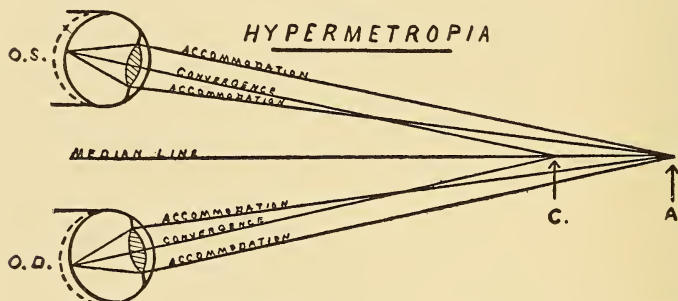
In Fig. 53 the darts, "A" and "C," show that binocular vision would be impossible under these conditions, and so individuals having eyes of this kind must learn to either decrease *convergence* or increase *accommodation* in an independent manner. This relative effort is shown by the position of the darts in the *neurometer*, Fig. 55, the nervous impulse here being much greater for *accommodation*.

In Fig. 56 the lack of harmony between darts "A" and "C" indicates that in *myopia* *accommodation* must be decreased or *convergence* increased before the two can be brought together.

Fig. 57 shows a relative adjustment of *innervation* to which nature undoubtedly resorts in cases of this kind.

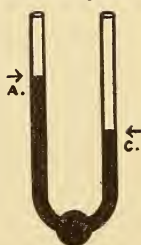
With an understanding of the disturbance in *innervation* which a *hypermetrope* or *myope* has to make in order to con-

FIG. 54.



IMBALANCE OF ACCOMMODATION AND CONVERGENCE IN HYPERMETROPIA.

FIG. 55.

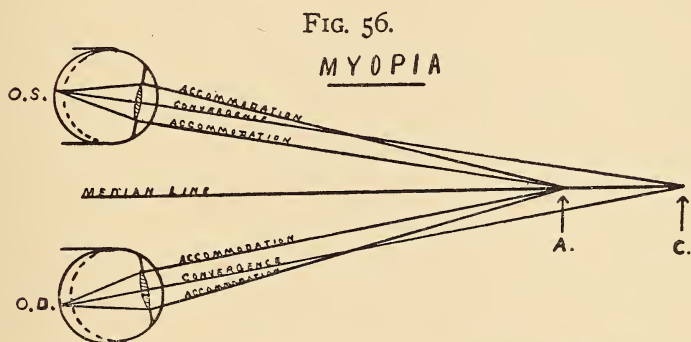


UNEQUAL INNERVATION REQUIRED TO BALANCE ACCOMMODATION AND CONVERGENCE IN HYPERMETROPIA.

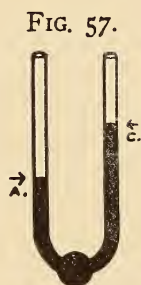
stantly maintain binocular vision, it is quite easy to see how readily an individual can form habits of muscular action controlling *accommodation* and *convergence* which would prove most difficult of reformation. And this leads the reasoner to

a general consideration of so-called "*spasms*," "*latent errors*," "*muscular insufficiencies*," etc., etc.

It also serves to emphasize the importance of keeping errors of refraction under constant correction, thereby enabling indi-



IMBALANCE OF ACCOMMODATION AND CONVERGENCE IN MYOPIA.



UNEQUAL INNERVATION REQUIRED TO BALANCE ACCOMMODATION
AND CONVERGENCE IN MYOPIA.

viduals to form new ocular muscle habits which will be in accord with standard visual requirements. Then, too, it will show the wisdom of postponing the adaptation of *prisms* until after old habits have been broken up by altering the conditions responsible for them.

CILIARY SPASMS, ETC. In arguing against the use of *cycloplegics* some optometrists are inclined to question the frequency of *spasms* and *latent* errors and to contend that their importance is overestimated, but familiarity with *static* and *dynamic skiametry* will soon prove the contrary. Spasms are defined as: "*Involuntary convulsive contraction of muscles,*" and "*convulsion,*" in turn, is described as "*irregular and violent commotion.*" Now, this latter definition might perhaps be modified a little and thereby convey a somewhat better understanding of the term *spasm*, as it is used here.

Owing to the contractile quality of muscles, they can only do one thing, and that is to *pull*, not *push*. Therefore, when the term "*violent commotion*" is used, it is immediately associated with the idea of a rapid and intense muscular activity, which resembles the seizures of *epilepsy*, and wrong impressions are apt to be formed.

As before stated, *spasms* can be of two kinds—the steady and the vacillating. So, where the word *tonic* is used in connection with them, they are to be associated with the idea of an *unconscious, involuntary, regular, steady and persistent muscle tension*.

Where the word *clonic* is used, however, it should be understood to mean *unconscious, involuntary, irregular, contracting and relaxing muscle action*, which, when taken in connection with the so-called *accommodation* of an eye, may be either rapid or slow in its operation.

The term *tonic spasm of accommodation*, as understood to-day, bears a close resemblance to what many readers of Donders are led to infer from his use of the term "*laten*" in connection with *hypermetropia*, for the word "*tonus*," from which the word "*tonic*" is derived, signifies an involuntary condition which might be likened to increased vigor or *tone* in a muscle whereby it may insist on doing more work than is really intended for it. This, of course, is alike applicable

to *myopic* and *emmetropic* eyes, though not occurring with the same frequency as in *hypermetropic* ones.

The cause of these *spasms* is also a varying one. In *hypermetropia* the constant muscle tension required in order to maintain vision is no doubt a pronounced factor. In *myopia* and in *emmetropia* an uncontrollable supply of nervous energy actuating the muscles is probably one reason for their involuntary contraction. Occupation, too, which leads to the formation of muscle habits, is undoubtedly another cause, and so quite a number of reasons might be suggested. The work of the optometrist, however, deals only with the determination of their presence and the estimation of their strength or influence on the refraction of an eye.

Reference has been made to the use of a local toxicant, technically termed a "*cycloplegic*," which is employed to paralyze the muscle action of an eye, but the drawbacks attendant upon the use of this means are so many, both from a practical as well as a theoretical standpoint, that some method had to be devised in order to eliminate the *guess work* which must necessarily enter into all cases where the exact refraction of an eye at its *reading* or *working* point is not known. And by "exact refraction" is meant the muscle *tonus*, or muscle *innervation*, which constitutes an individual factor in each case.

By *subjective* methods, if the patient is of sufficient intelligence and shows the proper amount of interest in the case, a cross-examination in connection with other tests will enable an examiner to form a fairly satisfactory idea of the range of *accommodation*, and from this known range he can make a close estimate as to the strength of the glasses required. But by the method known as *dynamic skiametry* a more certain estimate can frequently be arrived at, for by this examination the burden of judgment is shifted from the shoulders of the

patient to those of the examiner who, as his experience increases, should be a better judge of his patient's needs than the patient himself.

In the *dynamic* method attention has been called to the fact that where the muscles controlling *accommodation* were heavily taxed it was easy to see how readily they might be induced to surrender any excess of energy which they had hitherto concealed, no matter whether this concealment was total, in the form of a *tonic* muscle effort, or intermittent in the form of a *clonic* one.

Attention will be invited in another chapter to the advantages to be derived from the use of *mobile*, rather than of *fixed*, *lens values*, and this may serve to make this point plainer, for *spasms of accommodation*, especially of the *clonic* variety, require a lens action which will in a measure imitate the increase and decrease in convexity of the *crystalline lens* of an eye itself. To deal successfully with spasms, an examiner must, therefore, use some means which will enable him to make his lens changes in a gradual, rapid and accurate manner, and at the same time operate at any desired distance from his patient.

Then, too, if *habits* are to be broken up, the patient must be required to make some refractive adjustment that is unusual, and differing from the manner in which his eyes have been generally employed.

Many persons with uncorrected *hypermetropia* use their eyes as little as possible for reading or near work. Their muscle adjustment for distance, however, is almost a constant quantity during their waking hours. If such a person is young, and the ocular muscle action is vigorous, a *static* test, without *cycloplegia*, made at twenty feet is very likely to uncover only a portion of the error, for the reason that the

accommodation muscles have been so in the habit of exerting themselves at this distance that when lenses are supplied which remove the necessity for this exertion these muscles seem to refuse much of the assistance offered them.

On the other hand, if this case is examined *skiascopically* at a distance nearer than that of the usual reading point, it will be observed that the eye will now accept lenses very much stronger, for here *habit* is not such a factor, and under the burden of increased muscle effort the *accommodation* will readily give up the excess tension which it was so accustomed to exert for distant uses. Thus, *habit* being temporarily broken, the muscles governing *accommodation* and *convergence* are more likely to assume standard relations, and especially so if a lens system is used which permits of binocular mobile action.

In *myopia*, particularly in those cases which have remained uncorrected for a number of years, the *accommodation* is likely to prove disappointing in its action by behaving either spasmodically or quite the reverse. For this reason greater care must be exercised, when measuring these cases, to employ corroborative methods. A *myopic* case can seemingly be readily changed into a *hypermetropic* one by over-correction of the error, but muscle habits formed through ordinary occupations cannot be changed in a minute, and this fact must ever control the judgment of an examiner and cause him to adopt such methods and measures as will give him the fullest information regarding the requirements of each and every case that presents itself.

Of the two forces, *accommodation* and *convergence*, the former is probably the controlling one. So-called "*muscular insufficiencies*" are, therefore, doubtless the result of incoordination between the *ciliary* and the *recti* groups. If the theories as illustrated by Figs. 52 to 57, inclusive, are correct ones, then the fallacy of adapting *prisms* for the purpose of permanently assisting the muscles controlling *convergence* is

made plain for many cases, for where the error of refraction is not fully corrected it is logical to expect that the muscles controlling *convergence* will not behave in accordance with standards which are applicable only in *emmetropia*.

Where the *recti* muscles are mal-attached to the eyeball, or where there is a permanent deficiency in the amount of their *innervation*, then *prisms* would seem to be indicated, but experience teaches that these cases are rare. It is wise, then, for an examiner to correct his patient's refraction first and wait for the muscles governing *accommodation* and *convergence* to adapt themselves to the new order of things. If they fail to do this, and the examiner is sure that the error of refraction is fully corrected, then, and only then, is he warranted in the use of *prisms*, unless for the accomplishment of some temporary result.

While *adduction*, *abduction* and *sursumduction* offer important data by which to aid an examiner's judgment, they are usually of little avail until after *emmetropia* has been established and maintained long enough for *accommodation*, *convergence* and *innervation* to have ordinarily acquired a *habit* indicative of normal muscle balance.

To make these points plain it can be seen that if the relative proportion of three degrees of *convergence*, or *one meter angle*, to one diopter of *accommodation* is taken as a standard of estimation, then eyes having one diopter of *hypermetropia* in reading at a distance of sixteen inches away, which calls for two and a half diopters more, must make an *accommodative* effort equal to three and one-half diopters in all.

This ciliary action would call for a harmonious *convergence* equal to about ten degrees, and ten degrees, in turn, would call for a reading distance of eleven inches away, thus showing that while the eyes were *accommodating* for sixteen inches they would really have to *converge* to a point five inches

nearer in order to use a standard or proportionate amount of nervous energy; and as this would be quite impossible without disturbing binocular vision, hence the only other course left is for the *innervation* of the *convergent* muscles to be correspondingly decreased.

As *emmetropic* eyes cannot alter their co-ordinate muscle action without previous training, it would seem to be reasonable to assume that *ametropic* eyes ought also to require an equal time and training in order to enable them to convert their *latent* errors, or those due to habits of suppression, into *manifest* ones, or those within the individual's own control.

To what extent *habit* interferes with the accuracy of *static skiametry* must be left to the imagination of those examiners who have not yet had opportunities of personal observation. And while *dynamic skiametry* offers a marvelous improvement in estimating the true refractive errors of young persons, it, too, is frequently interfered with by this same disturbing factor of *habit*, or "*individual equation*," as it is sometimes called.

It must not be overlooked, however, that, even after *latent* errors have been determined, and *spasms* unlocked, it is not always wise to endeavor to force eye muscles to accept standard relationship in too short a period of time, for while it is true that usually the best results are obtained after *emmetropia* and *orthophoria* have been established, yet it is equally true that, in some cases, it is better to ignore a small *spasm* and permit the muscles to work, for a while, in excess of normal requirements.

This, therefore, indicates that optometric findings are one thing and the *judgment used* in adapting glasses and prisms is quite another. For with the experienced examiner it often happens that in youthful cases he may find an error of perhaps four diopters of *hypermetropia* by the *dynamic* method, and yet correct only two diopters of this in the first glasses given, taking several months of time in order to educate the eye

muscles up to a normal standard where they can bear a full correction of their refractive errors.

The making of the original examination in a thorough and reliable manner will thus be seen to greatly assist an examiner in prognosticating his cases, as well as in giving advice the correctness of which will be borne out in due course of time.

There is an old adage which says that "*it takes a long time to teach old dogs new tricks,*" and the reason for this lies, perhaps, in the fact that before *new habits*, or "*tricks,*" can be formed the old ones must be *broken up*, and this in some cases may be more of a task than even the formation of the new. *Spasmodic* muscle action, while unimportant in some cases, is quite the contrary in others, so that the wise examiner will take no chances, but proceed to thoroughly master *all* of his cases. Any unsatisfactory results that may occur can then be attributed more to faulty judgment than to a lack of knowledge of the optical and correlated *intrinsic* and *extrinsic* muscle action involved.

CHAPTER VII.

PRACTICE OF DYNAMIC SKIOMETRY, ITS USE IN MEASURING
REGULAR AND IRREGULAR ASTIGMIA, AND ITS SPECIAL
VALUE IN THE OBJECTIVE ESTIMATION OF PRESBYOPIA
AND SUB-NORMAL ACCOMMODATION, TOGETHER WITH ITS
RELATIONSHIP TO OTHER METHODS AND TESTS.

PRACTICE OF DYNAMIC SKIOMETRY. It is unquestionably true that no other one instrument in the armamentarium of an optometrist requires more practice to successfully master than does the *skiascope*, and, it might be added that the *dynamic method* requires much greater skill in order to read the shadow's action than does that of the *static*. The reason for this is to be found in a consideration of the subject of *retinal illumination*, for it is well known that the shorter the distance between the *light source* and the patient's eye the larger and brighter will be the area of illumination on the *fundus* of the eye under examination. This, taken in connection with the optical laws regulating *penumbra*, and the variation in *retinal pigmentation*, together with size of *ocular pupils*, added to light stimulation, will show why the nearer a shadow test is made the more difficult becomes the reading.

If it was not for the erratic relationship that frequently exists between *accommodation* and *convergence*, and for the irregularities existing in *corneal curvatures*, then the *static* method would be the best to use, and the greater the distance it was employed the better the results would be. But *skiometry*, like many other systems, has to be taken *as it is*, and not as the operator or patient would like to have it.

Practice, plenty of practice, the same as one becomes expert

in shooting a gun, or in making examinations by *indirect ophthalmoscopy* is the only way in which an examiner can become skillful in *skiametry*. The general variation in appearance of eyes is such that a comprehensive description of all kinds is almost impossible, the student must, therefore, see for himself. But to put into words a description of the procedure necessary in making an examination by the *dynamic method* the following may give a better understanding.

In order to secure as favorable a *fundus reflex* as possible, place the *fixation-stand target card* forty inches from the patient's eyes and then make the first skiascopic *observation* from a point about two or three inches to the left of this card and an inch or so nearer the patient. If motion *against* is not present then *add plus spheric lenses* until motion *against* occurs in some meridian. The strength of the lens *next weaker* than the one that just causes the *against* motion is the one that represents the error for this distance in the meridian measured.

If, on the other hand, at the first *observation* an *against* motion is noted, then, with the patient still looking at the *fixation-stand card*, the examiner is to advance toward the patient until a *with* motion is obtained in some one meridian. This distance, estimated in diopters, less the 1. D. of *accommodative myopia*, due to the *forty-inch fixation*, will represent the *true myopia* for the meridian measured, and if *astigmia* is present all the meridians will not measure alike.

After this first estimation of the error, or errors, the examiner is to place the estimated correcting lenses in position on the patient's face and make a *subjective* test, after which he is to return to *skiametry* again and make another examination at a reading or much nearer point than the first one was made, using the *fixation cards* on his *bracket skiascope*. The changing back and forth from *objective* to *subjective* and from *subjective* to *objective* will be seen to give all the refractive data that it is possible to obtain, after which the use of other instruments and

methods may, or may not, be indicated, as their necessity is usually determined by the previous findings.

Two typical cases may possibly make these points plainer: CASE 1. Age of patient, thirty years. *Fixation*, forty inches. *Observation*, thirty-nine inches. Shadow *with* the mirror. Can add plus 1. D. before *reversal* occurs. *Subjective* test also shows 1. D. of *hyperopia*. But with *fixation* and *observation* at sixteen inches, a total of plus 1.50 D. can be added before *reversal* takes place. Same result is obtained when *fixation* and *observation* are at thirteen inches. CASE 2. Age of patient, thirty years. *Fixation*, forty inches. *Observation*, thirty-nine inches. Shadow shows *against* the mirror. *Reversal* takes place at twenty inches which, after deducting 1. D. for the *accommodative myopia* at forty inches, leaves 1. D. of *true myopia*. *Subjective* test calls for a minus 1.50 D. S. lens. *Fixation* and *observation* at sixteen inches show a *with* motion with a minus 0.75 D. S. lens, and at thirteen inches a minus 0.50 D. S. lens is the weakest one a *with* motion can be obtained with. The student must not forget, however, that *data* and *prescription* are not always one and the same.

MEASURING REGULAR AND IRREGULAR ASTIGMIA BY SKIAMETRY. The variation in the appearance of *astigmatic* eyes is often baffling to the *skiametrists*. Some shadows show an even edge that makes their measurement most easy, while others scatter and re-form several times in crossing over a pupil. The cause for this can perhaps be found in a consideration of *scar tissue*, for where reliable history of many cases of this kind has been obtained it is found that in childhood the patient suffered from inflamed eyes, and the *sequela* was the irregularly thickened *corneal tissue* which manifests itself in unequal refraction.

A study of these cases with the *skiascope* will often enable an examiner to cope with those which at first seem almost hope-

less, and this rule holds good with all classes of *skiametric* cases, no matter what method is used. The *skiametrists* must simply perfect his skill by ample practice.

When the conditions are ideal an examiner will be able to note a sort of straight edge action to the shadow. If the error is marked then this edge will be well defined, but if the error is slight then the edge will be difficult to note.

In those cases where what is called the "scissors" movement appears an examiner will observe two shadows in one meridian, one *with* the mirror and the other *against*. This is frequently caused by making the *observation* too far to one side of the line of *fixation*, especially where the correcting lenses used are of high power.

The generally accepted theory of the cause of the "scissors" movement attributes it to the *crystalline lens* being slightly askew in its capsule, but if an examiner will keep the lines of *observation* and *fixation* as near together as it is possible and obtain a good *fundus reflex* he will find that true *crystalline* displacements are quite rare.

In partially *opaque corneas*, and in cases of *cortical cataract* where transparency is interfered with, an examiner will often be rewarded through results obtained by careful work with his *skiascope*. *Cataracts* in process of development can often be detected, too, long before the vision of the patient is perceptibly impaired. The *spicula* in the *crystalline* showing translucent upon the red background of the pupil, and especially do they appear plain when mechanical *mydriasis* is made use of.

MEASURING PRESBYOPIA BY SKIAMETRY.

Presbyopia is usually regarded as an *infirmity*, rather than as an *error of refraction*, but it can also be considered in the latter light, too, for research proves that the *crystalline* changes begin almost at birth and continue all through life. Loss of elasticity due to changes in density and to production of an altered

index surely indicate *refractive* variations, and as the only difference between lenses of like kind is variation in ray-bending power, therefore *presbyopia* would seem to rightfully belong under the classification of *refractive anomalies*, just as much as under *accommodative* anomalies.

Presbyopia is the one, so-called, "easy" ocular condition that is often the most difficult of satisfactory correction, for the reason that *occupation, illumination, habit, pupillary distance* and *innervation, or bodily vigor*, are all factors to be reckoned with. Then, if combined with this the ignorance and stupidity of many patients in answering questions is taken into consideration, it is easy to see why changes in reading glasses are so frequent when "there's nothing the matter with the eyes."

Up to the time of the development of the *dynamic* method of practising *skiametry* there was no known method of estimating *presbyopia* in an *objective* manner. All *static* methods, whether with or without *cycloplegia*, are solely for determining the refractive condition of an eye while its muscles are in a state of complete relaxation, therefore the *static* method gives no definite aid in *presbyopia* whatsoever.

Dynamic skiametry supplies the refractionist with a method that often proves of the very greatest aid in mastering a troublesome case, as it enables the eyes to be studied at all points, near as well as distant, this study being directed toward steadiness of *convergence* and *accommodation*, both of which can be detected through the use of a *skiascope* and *lenses*. As illustrative of this, suppose a case presents itself having a history of discomfort in reading, etc., the patient is directed to look at the *skiascope fixation-card* fourteen inches away while plus one-diopter *spheric* lenses are before each eye. If right eye shows a *with* motion while left eye is *against*, it indicates either an error of refraction or an unequal *innervation* of the muscles controlling *accommodation*, notwithstanding that at infinity both *error* and *vision* seemed alike in the two eyes. The

use of the mirror at this distance also enables the detection of any deviation in *convergence* of either eye when *fixation* for this point is maintained for a considerable time.

It is conceded, of course, that it takes more *skiametric* skill to measure an eye at fourteen inches than it does at forty, but that which is possible for one examiner is also possible for another with equal intelligence and perseverance. *Dynamic skiametry* being particularly adapted to the needs of those who are advanced in *optometric* knowledge and skill.

SUB-NORMAL ACCOMMODATION. In comparatively recent years that which was formerly called "*latent*" *hypermetropia* has been classed as an early or *sub-normal accommodation*, and practitioners of repute are now adapting bi-focal lenses to young persons with great success in some cases.

To the optometrist it matters little whether the patient's inability to see nearby objects is caused by *latent hypermetropia* or by an early change in the *index of refraction* of the *crystalline*, or by a weakened muscle action, what he needs to know is the true condition of the refraction at *all* points, *near* and *distant*, and then by keeping the patient under observation it can be determined whether the case is one requiring the aid of the family physician or of the ophthalmic specialist.

As in *presbyopia*, *dynamic skiametry* instantly detects a *lag in accommodation*, and if this "*lag*" is present it needs looking after.

A case is reported of a young Miss, fifteen years old, who was behind in her school work. She had been *atropinized* and fitted with O. .U. plus 1. D. S. lenses for constant use. So-called "*retinoscopy*," in the hands of an optometrist who thought well of his own ability, confirmed the findings of the oculist who prescribed the glasses. *Static skiametry* also confirmed the prescription given. *Dynamic skiametry*, however, showed that a plus 3. D. S. lens was indicated at thirteen

inches. Plus 2. D. S. lenses, O. U. worn for a month did not succeed in relaxing any more than the original correction for infinity. Bi-focals of plus 1. D. S. upper and plus 3. D. S. lower gave almost perfect results after this form of glass had been worn a few weeks. *Adduction* and *abduction* were both poor, but the eyes were *orthophoric*. If *dynamic skiametry* had not been used in this case the chances are that it would have gone the way of many others, and the patient allowed to suffer on.

Perhaps a stronger *cycloplegic*, or a long period of wearing *fogging* lenses would have revealed more *latent* error, but the indications were that this was a case of what is termed "*pre-mature presbyopia*" or "*sub-normal accommodation*," and *dynamic skiametry* was the only method by which it could be intelligently *refracted*.

OTHER TESTS. It may do no harm to repeat once more that no one *optometric* test is the "whole thing," as the urchins say. The definition of the word *optometry*, it must not be forgotten, is eye-measuring. That of *skiametry* is shadow-measuring, and as the word *ocular* means eye, it will therefore be seen that *ocular-skiametry* is only one division of *optometry*, and that the *dynamic method* constitutes merely a sub-division.

If all divisions of a subject bear an integral relation to the whole, then *dynamic skiametry* is but one means for obtaining data which, together with that secured by other methods, contributes to the formulation of the proper prescription, and "proper prescription" means the glasses that are best for the patient to use. Thus, if by *subjective* measurement the patient says that his vision is improved by the use of a convex *spheric* lens of two diopters, but by *keratometry* a mal-curvature of a half-diopter of the *cornea* is shown, and by *dynamic skiametry* a three-diopter convex *spheric* is called for, then it may be wise to prescribe a two and one-half *sphere*, especially if the patient

has been wearing a partial correction and gives a history of eye-strain.

It is the combination of important factors in a given case that often makes success possible. Blind adherence to any one test, or method, is no doubt responsible for many *optometric* failures. *Duction tests* of the muscles give data that have great influence in determining the strength of lenses to be prescribed, even though *prisms* are not used, and where *heterophoria* is present the data secured by means of *dynamic skiametry* may often save the prescribing of *prisms*.

The aim of the thorough-going optometrist should be to determine as carefully as possible the true condition of his patient's eyes. And this involves many tests in some cases and few in others, for a case of simple *presbyopia*, with standard vision and no history of discomfort, does not need the time nor the many tests that are indicated where the *ametropia* is complex and the history of general health and nervousness poor.

Of course the treatment of impaired health of a patient is foreign to the service that an optometrist is generally consulted for, but a "poor history" forms data that has an indirect bearing upon all *optometric* cases, so the wise examiner acquaints himself with *all* tests and methods that will aid him in the formation of correct judgment, for, after all, it is this "judgment" which makes one succeed where another fails.

Perhaps one of the hardest strains a new method has to stand is the extravagant claims made for it by enthusiasts. Take the *keratometer* for instance, a very valuable instrument but often most unreliable where its findings are blindly adhered to. One great mistake made by many practitioners of optometry is that they do not take their profession seriously enough. It seems so easy to use a few instruments, ask a question or two and then form *snap* judgment as to a *patient's*

requirements, therefore it is little wonder that this field attracts to it many incompetents.

As optometry develops, however, it is hoped that the general public will grow wiser and learn to reward those who give the time and make the effort to fully master each and every detail that has direct and indirect bearing upon the practice of optometry in its larger sense.

CHAPTER VIII.

ILLUSTRATIVE CASES, SHOWING THE COMPARATIVE VALUE OF
STATIC AND DYNAMIC SKIAMETRY IN PATIENTS OF DIFFERENT AGES, OCCUPATION AND GENERAL PHYSICAL CONDITION.

ILLUSTRATIVE CASES. The expression "Figures talk" is especially applicable in describing the relative merits of *static* and *dynamic* methods in practising *ocular skiametry*. Space, therefore, will here be devoted to descriptions of various cases for the purpose of emphasizing points already alluded to, and of incidentally calling attention to the influence of *occupation* and the importance which attaches to the condition of the patient's *general health*. All the examinations referred to were made without the aid of *cycloplegics*, consequently the *static* test mentioned is the non-toxic kind.

CASE A.

Master S., age 7. In school. Health, seemingly good; O. S. shows slight *convergent squint*.

Vision = O. D. 20/20. O. S. 20/100.

Static test = O. D. + 2.50 D. S. O. S. + 3. D. S.

Dynamic test at forty inches = O. U. + 3.50 D. S.

Dynamic test at twenty inches = O. U. + 4. D. S.

Dynamic test at thirteen inches = Unsatisfactory.

Trial case test = O. D. + 2. D. S. O. S. + 3. D. S.

Vision = O. D. 20/20. O. D. 20/80.

Formula given = O. U. + 3. D. S. for constant use, with instructions to return in one year.

Two years later O. U. + 3.50 D. S. was readily accepted.
No squint.

Vision = O. D. 20/20. O. S. 20/40.

CASE B.

Master W., age 11. Health not rugged. Inability to see blackboard.

Vision = O. U. 20/100. *Static* test = O. U. — 1. D. S.

Dynamic test at 13 inches = O. U. — 0.50 D. S.

Trial case test = O. U. — 1.25 D. S.

Vision = 20/20 in both eyes.

Formula given = O. U. — 0.50 D. S. for constant use.

Instructed to return in three months.

Six months later vision O. U. = 20/20 with

O. D. — 0.75 — D. S.

O. S. — 0.75 — D. S.

CASE C.

Miss N., age 16. In school. Health fair. Headaches.

Vision = O. U. 20/30.

Static test = O. U. + 0.50 D. C. 90°.

Dynamic test at 16 inches, same.

Trial case test = O. U. — 0.50 D. C. 180°.

Vision = 20/20 in both eyes.

Formula given = O. U. + 0.50 D. C. 90°.

Vision = "misty."

Instructed to use at study, and oftener if more comfortable.
Later on she reported "no headaches," and vision was found to be 20/20 with glasses.

CASE D.

Mr. G., age 20. In college. Reports his health good. No discomfort, but "can't see at a distance."

Vision = O. U. 20/200.

Static test = O. U. — 2.50 D. S.

Dynamic test at 40 inches = O. U. — 2. D. S.

At 16 inches, about the same.

Trial case test = O. U. — 2.75 D. S.

Vision = 20/20 in both eyes.

Formula given = O. U. — 2. D. S. for constant use.

Instructed to return if he had any further trouble. No report.

CASE E.

Mr. S., age 24. Mechanic. Something of an athlete; complains of headache.

Vision O. U. = 20/20.

Static test O. U. = + 1.25 D. S. $\ominus$ + 0.25 D. C. 90°.

Dynamic test at 13 inches =

O. U. = + 2. D. S. $\ominus$ + 0.25 D. C. 90°.

Trial case test O. U. = + 1. D. S. $\ominus$ + 0.37 D. C. 90°.

Vision = 20/20.

Formula given O. U. = + 1. D. S. $\ominus$ + 0.25 D. C. 90°.

Advised to return in one year, which he did, and was given

O. U. = + 1.50 D. S. $\ominus$ + 0.25 D. C. 90°.

Advised to return again within two years.

CASE F.

Miss F., age 26. Seamstress. General health not good. "Weak eyes."

Vision = O. D. 20/40. O. S. 20/80.

Has been using O. U. + 1. D. S.

Static test =

O. D. + 0.50 D. S. $\ominus$ + 2. D. C. 90° .

O. S. + 2. D. S. $\ominus$ + 2. D. C. 105° .

Dynamic test at 40 inches =

O. D. + 1. D. S. $\ominus$ + 2. D. C. 90° .

O. S. + 3. D. S. $\ominus$ + 2. D. C. 105° .

Dynamic test at 20 inches =

O. D. + 1.50 D. S. $\ominus$ + 2. D. C. 90° .

O. S. + 3. D. S. $\ominus$ + 2. D. C. 105° .

Dynamic test at 13 inches = Same

Keratometer = O. D. 2. D. 90° . O. S. 2. D. 110° .

(Note difference in axis of O. S.)

Trial case test =

O. D. + 0.25 D. S. $\ominus$ + 2. D. C. 90° .

O. S. + 1.50 D. S. $\ominus$ + 2. D. C. 105° .

Vision = O. D. 20/20. O. S. 20/40.

Formula given =

O. D. + 1. D. S. $\ominus$ + 2. D. C. 90° .

O. S. + 2.50 D. S. $\ominus$ + 2. D. C. 105° .

Instructed to wear constantly and to "never mind if distant objects are a trifle blurred for a few weeks." Returned in a week with a history of occasional discomfort. Gave advice to persevere. Returned in four months with a broken lens and wanted a new one "immediately." Glasses were very satisfactory. Vision = O. D. 20/20. O. S. 20/40.

CASE G.

Mr. C., age 29. Bookkeeper. Reports health good when not working too hard. Eyes and head "feel bad" afternoons. Has been wearing glasses for three years of the following formula:

O. D. — 1. D. S. $\ominus$ + 2. D. C. 75° .

O. S. — 1. D. S. $\ominus$ + 1.50 D. C. 105° .

Vision with present glasses = O. U. 20/30.

Fundus reflex very poor.

Keratometer shows = O. D. 2. D. axis 75° . O. S. 2. D. axis 105° .

Dynamic test at thirteen inches, with trial lenses, shows the myopic quantity to be only 0.50 D. in both eyes.

Trial case test =

O. D. — 1. D. S. $\ominus$ + 2. D. C. 75° .

O. S. — 1. D. S. $\ominus$ + 2. D. C. 105° .

Vision = 20/30.

Formula given =

O. D. — 0.50 D. S. $\ominus$ + 2. D. C. 75° .

O. S. — 0.50 D. S. $\ominus$ + 2. D. C. 105° .

Vision = "Foggy."

Report received in two weeks: "All right now."

CASE H.

Mr. R., age 34. Grocer. History of health unsatisfactory. Vision poor for past few months.

Present vision = 20/80 in both eyes.

Static test =

O. D. + 1. D. S. $\ominus$ + 0.50 D. C. 180° .

O. S. + 1. D. S. $\ominus$ + 0.50 D. C. 180° .

Dynamic tests, at 40 and 16 inches, about the same. Trial case, about the same.

Optical correction no material aid to vision. Ophthalmoscope shows pale discs. Close questioning leads to conclusion that it is a probable case of nicotine poisoning, due to immoderate smoking aggravated by the moderate use of alcohol. Gave no glasses. Advised to consult an oculist first.

CASE J.

Miss B., age 38. Stenographer. Says health is good except for headaches.

Vision = O. U. 20/20.

Static test = O. U. + 0.50 D. S.

Dynamic tests at 40 and 16 inches = O. U. + 0.75 D. S.

Trial case test = O. U. + 0.25 D. S.

Vision = 20/20 trifle "hazy."

Formula given = O. U. + 0.50 D. S.

For reading and near work. Good report.

CASE K.

Mrs. A., age 41. Has household cares only. General health none too good. Complains of inability to see to thread her needle and do fancy work. No headaches.

Vision = O. U. 20/20.

Dynamic tests at 40 and 16 inches = O. U. + 1. D. S.

Trial case test = O. U. + 0.75 D. S.

Vision = 20/20.

Formula given = + 1. D. S. for both eyes.

Instructed to use for near work. No report.

CASE L.

Mrs. L., age 46. Housekeeper. Health appears good. Difficulty in reading. No headache.

Vision = O. U. 20/20.

Static test = O. U. + 0.25 D. C. 90°.

Dynamic test, at 40 inches, about the same. Trial case, about the same.

Dynamic test at 15 inches = + 1. D.

Formula given = O. U. + 1. D. S. $\subset$ + 0.25 D. C. 90° for reading, etc. No report.

CASE M.

Mr. D., age 52. Court stenographer. Health seemingly good. Never has had any glasses that proved quite satisfactory.

Vision = O. U. 20/80. *Dynamic* test at 50 inches =

O. D. + 1.25 D. S. $\ominus$ + 0.25 D. C. 135° .

O. S. + 1.25 D. S. $\ominus$ + 0.25 D. C. 90° .

Trial case test, the same. Vision = O. U. 20/30.

Presbyopia = 2.25 D. Gave bi-focals.

Reported in sixty days that vision was good but glasses did not seem quite right. "Guessed" he was working too hard.

Re-examination by *dynamic* test at 30 inches =

O. D. + 1.50 D. S. $\ominus$ + 0.25 D. C. 120° .

O. S. + 1.75 D. S. $\ominus$ + 0.25 D. C. 80° .

Vision = O. U. 20/20.

Presbyopia = 2. D.

Reported in six months "O. K. now, 'twas the glasses after all."

CASE N.

Mr. O'B., age 55. Driver. Health good. "Can't see."

Vision = O. U. 20/80. *Static* test = O. U. + 1.50 D. S.

Presbyopia = 2.50 D.

Trial case test = O. U. + 1.50 D. S.

Vision = 20/20.

Formula given = O. U. + 4. D. S. for reading. Would not wear distance correction.

No report.

CASE O.

Mr. E., age 59. Tailor and cutter. Health good. Working distance about twenty inches away. Present glasses are + 3. D. S. for both eyes, and are not very satisfactory.

Vision = O. D. 20/30. O. S. 20/100.

Static test =

O. D. + 0.50 D. S.

O. S. + 1. D. S. + 1. D. C. 180° .

Keratometer shows no corneal mal-curvature in either eye.

Trial case test, same as *static* test.

Vision = O. D. 20/20. O. S. 20/40.

Presbyopia at working distance = 2. D.

Presbyopia at reading distance = 2.75 D.

Formula for working glasses =

O. D. + 2.50 D. S.

O. S. + 3. D. S. + 1. D. C. 180°.

Formula for reading glasses =

O. D. + 3.25 D. S.

O. S. + 3.75 D. S. + 1. D. C. 180°.

Instructed to return if not satisfactory. No report.

CASE P.

Mrs. M., age 62. Occupation (?). Health (?). Looks well.

Vision less than 20/200 in both eyes.

Static test: First attempt, no *retinal reflex*. Without skiameter the mirror shows small pupils and slow plus movement. With *skiameter*, lenses being set to enlarge the pupils, better movement is obtained and long, narrow, spike-like patches show. Error about + 4. D. S. in both eyes.

Trial case test = O. U. + 3.50 D. S.

Vision = O. D. 20/40. O. S. 20/60.

Presbyopia = 3. D.

Ophthalmoscope shows slight cortical cataracts.

Gave formulas: Distance = O. U. + 3.50 D. S.

Reading = O. U. + 6.50 D. S.

With instructions to be sure and have a strong light coming over shoulder when reading or sewing. Sent letter to family physician.

CASE Q.

Mr. McE., age 67. Health fair. Retired. Now using glasses + 4. D. S. for reading; wonders if they can be improved.

Vision = O. U. 20/80, which is improved by partially closing the eyelids. *Static* test = O. U. + 1. D. S. Trial case test the same. Vision = O. U. 20/30. *Presbyopia* = + 3. D. S. Formula for distance = + 1. D. S. Advised to continue with present reading glasses and to increase his illumination when using his eyes for near purposes. No report.

NOTE.—According to Donders the near point of distinct vision in an *emmetropic* eye is as follows:

At 10 years of age it is	2¾ inches away.
" 20 " " " "	4 " "
" 30 " " " "	5½ " "
" 40 " " " "	9 " "
" 50 " " " "	16 " "
" 60 " " " "	40 " "

To illustrate in fuller detail the workings of *dynamic skiometry*, let the following case be analyzed.

Mr. H., age 25. Contractor's timekeeper. Leads outdoor life. General health excellent. Complains of occasional headache.

Vision = O. U. 20/20. *Static* test = O. U. + 1.25 D. S.

Dynamic test at 13 inches = O. U. + 2. D. S.

Trial case test = O. U. + 1. D. S. Vision = 20/20.

By reference to Fig. 54, it will be seen that when his *accommodation* and *convergence* each receive an equal amount of *innervation*, the *convergence* will be greater than the *accommodation*, and binocular confusion will result, thus giving rise to *esophoria* unless the *innervation* is altered in some way so as

to produce the condition called for by Fig. 55, where the *innervation* for *accommodation* is in excess of that for *convergence*. A test of his *extrinsic* muscles, however, shows a manifest *orthophoria* without glasses.

Now what are the deductions to be drawn from this case? Twenty-five years of daily use of the eyes without glasses has established a *habit* of adjustment whereby the standard relationship between *accommodation* and *convergence* has been replaced by a condition in which *convergence* has given way a little, otherwise *esophoria* would have manifested itself.

The *static* test shows a reversal of the shadow when over one and a quarter diopters of convex lens power are added. This is in addition, of course, to the quantity necessary to create the *artificial myopia*. Thus proving that *habit* has not mastered quite all of the error, as the *accommodation* readily accepts partial assistance and relaxes its muscle tension as much as five-eighths of the full *ametropia* present. The remaining three-eighths of the total error can be called *latent*, but in reality it represents a *tonic spasm*, a knowledge of the presence of which materially aids an examiner in the formation of his judgment and in the advice and prognosis he is enabled to give a patient.

To determine the amount of *tonic spasm* present in a case, such as the one under consideration, it will be necessary to resort to the *dynamic* method which calls for a pronounced exertion of the patient's *accommodation*.

An *emmetrope* twenty-five years of age is supposed to have about eight diopters of *amplitude of accommodation*. The nearest point of distinct vision is then five inches away from the eyes. A *dynamic* test made at thirteen inches calls for an *accommodation* equal to three diopters. The patient's error being two diopters, it follows that a total ocular muscle exertion equal to five diopters is necessary in order to enable the patient to distinctly read small letters on a card whose distance away is the same as that of the examiner's mirror.

More than five diopters of *accommodative* effort can, of course, be exerted by the patient in this case. Yet this amount will generally be found quite sufficient to break up any *tonic spasm*, or *habit of muscle exertion*, that may have been formed. Five diopters less three diopters leaves two diopters, and a lens quantity of this strength should reverse the shadow by the *dynamic* test under these conditions.

If the test had been made at twenty inches, then four diopters would represent the total muscle effort called for. If at ten inches, then six diopters would be the full *accommodation* needed. The difference between these amounts and that required to maintain normal relationship between *accommodation* and *convergence* at whatever distance the test is made will show at once in the lens quantity required to reverse the shadow, provided the eyes are examined in a semi-binocular manner, namely, first one eye and then the other, alternating frequently so as to insure an equality of visual fixation.

One point which seems to puzzle many examiners who take an interest in making theory substantiate practice is to understand why an *emmetropic* eye when under an *accommodative* tension of three diopters at thirteen inches, will not relax to two diopters when one diopter of assistance is offered it. The answer to this query probably lies in a better understanding of *muscular co-ordination* and *innervation*, for, as stated in earlier chapters, the eyes of a healthy person, free from coercion, cannot *converge* without *accommodating*, nor can they *accommodate* without *converging*. And this co-ordinate relationship will respond to approximate standards unless long-standing abnormal requirements have induced irregular *habits*. In this latter case refractive measurements must be taken in such a manner as to estimate the real influence of these *habits* by making the eyes work, for the time being, in a manner as far removed from old beaten paths as possible.

Now another case will be cited in order that the details of *skiametric* procedure may be accentuated.

Mr. Z., age thirty-five, occupation watchmaker. Has been studying optics for two years. States that he has fitted himself with O. U. — 0.50 D. S. $\ominus$ — 0.75 D. C. axis 180° , that his vision without glasses is O. D. = 15/30 O. S. = 15/20, and that he has four degrees of *esophoria*.

As the above information, excepting the age, is supplied after the examination is finished, the examiner, of course, proceeds in the usual manner and directs the patient to look at the letters on a *fixation stand card* situated fifty-three inches distant. In an *observation* made at forty inches the examiner finds that in the right eye there is a fairly distinct edge to the shadow and that it points a little to the left of the *vertical* meridian. Adding *convex* lens quantity it is found that one diopter is needed to reverse the shadow in the *horizontal* meridian, and that in the *vertical*, with no lens power added, the motion is a trifle against the mirror. With the patient still looking at the *fixation card* fifty-three inches away the examiner finds that he must advance his mirror ten to fourteen inches nearer to his patient before he obtains a reversal of the shadow in this meridian. So he notes on his examination blank "O. D. — 0.25 D. S. $\ominus$ + 1. D. C. axis 105° ."

In the left eye the *horizontal* motion is reversed with a half-diopter *convex* lens quantity. In the *vertical* meridian there is a motion *with* the mirror, when the examiner is forty inches away. Adding even a slight *convex* lens power stops it. The axis seems to be about fifteen degrees to the temporal side of the head. The examiner notes "O. S. + 0.50 D. C. axis 75° ." Corroborating *subjectively*, it is found that vision O. U. 20/20, a trifle "misty," can be secured with O. D. — 0.50 D. S. $\ominus$ + 0.75 D. C. axis 105° and O. S. + 0.25 D. C. axis 75° . Patient reads well with this correction, and — 0.50 D. S. or + 0.50 D. S. added in a binocular way offers no aid. Corroborating

skiametrically again with the full correction on, it is found that a quarter-diopter *convex* lens reverses the shadow in all meridians when the patient looks at the *brow card* on the examiner's mirror, no matter whether its distance be twenty or forty inches away. With the quarter-diopter *convex* lens power removed, the shadow shows a suggestion of a movement *with* the mirror, at the same distances of twenty and forty inches away. The above formula is then ordered and the patient is instructed to wear the glasses as much as possible and to report in a month.

In analyzing this case the occupation of the patient is borne in mind as one calling for considerable *accommodative* adjustment. Then the previous wearing of concave lenses is perhaps partly responsible for the four degrees of *esophoria* complained of, for with these glasses on one end of the *astigmatic interval* in the left eye calls for one and a half-diopters of *accommodation* which, in turn, calls for two and a quarter degrees of *convergence* in order to maintain standard co-ordination. And this for one eye only.

The age of the patient, the *habit of excessive convergence* due to occupation, also the *habit of accommodation* aggravated by the occasional use of glasses calling for increased *ciliary* effort, are all factors to be considered by an examiner, especially if his patient returns in a day or two and complains of a "thin fog," etc.

The temptation to advise the immediate use of lenses which the optometrist feels sure represent the *full correction* of his patient's *ametropia* is very strong indeed, and if he has an intelligent patient to reason with this judgment is often correct. But if his patient happens to be of the timid kind, or one who thinks the acuity of vision to be had after one day's use of glasses is the only thing to judge their merits by, then it is wise to "*make two bites of a cherry*" and indulge the patient's own notions by giving a temporary correction slightly over or

under that which is really indicated, and which will eventually have to be given.

It is cases such as these that render the science of *optometry* inexact, for an examiner must always remember that attached to every pair of eyes is a *different* individual with a *different* body, a *different* occupation, *different* habits and *different* ideas as to *different* things, and so each patient requires *different* judgment and *different* explanations and encouragements.

And it is for these *differences* that in *optometry*, as in other specialties, "many are called and few are chosen."

CHAPTER IX.

MULTIPLE METHODS IN OPTOMETRY AND THEIR VALUE IN CORROBORATIVE MEASUREMENTS. — THE SYSTEMATIC KEEPING OF RECORDS AND THE IMPORTANCE OF "CASE HISTORY", INCLUDING RESOURCEFULNESS, AND MECHANICAL MYDRIASIS.

MULTIPLE METHODS. Eye-measuring embraces many "*metrys*" and the able optometrist must be master of them all. Even in the method to which the name *static* skiametry has been logically given there are many ways of applying its optical principles. The word "*static*," as is well known, is used to designate bodies at rest, or forces in equilibrium. The medical examiner attempts to induce this rest of the muscles, controlling the *accommodation* of an eye, by instilling into the *cul-de-sac* of this organ some one of a series of powerful toxicants, and thus, for the time being, practically transforming a living eye into a sort of schematic one.

Non-medical examiners, on the other hand, attempt the relaxation of this *accommodation* by having their patients look toward some distant object in order to thus coax the muscles into a condition of inactivity, and in further explanation it may be truthfully said that in many cases one overdoes the matter while the other underdoes it. The medical examiner's overdoing consists in forcing the eye into an abnormal condition in which the co-ordination of *accommodation* and *convergence* is temporarily destroyed, this destruction depending of course upon the strength of the drug used, and the duration and frequency of its instillation, as well as upon the *idiosyncrasies* of the patient. The results obtained by measuring the refraction

of an eye while it is in a state of what might be called "local intoxication" would seem to call for judgment of the very highest type in order to make the *theoretical* conform to the *practical*.

Regarding the non-medical examiner's manner of using the *static* method, especially in those cases where the muscle action is liable to be particularly vigorous, it can be likened to the old story of *the blind leading the blind*, for the reason that if the patient fails to maintain the requisite muscular relaxation the examiner has no means of knowing what action has really taken place, and his findings, therefore, are likely to prove very unreliable.

Spasms of accommodation, as they are termed, are probably responsible for more mistakes being made in the *non-toxic* manner of employing the *static* method than can be attributed to the carelessness of patients in looking, or in trying to look, at the object to which their attention has been directed.

In dealing with these cases there are two ways in which *static skiametry* can be used. One consists in beginning an examination with only that lens before the patient's eye which is necessary to produce the *artificial myopia* required for the operating distance, whatever that may be, and then, if the case is a *hypermetropic* one, the *convex* lenses are to be gradually increased in strength until the reversal point of the shadow is obtained.

If the case is one of true *myopia*, however, then an over-correction is necessary, and the *concave* lenses used for this purpose are to be gradually decreased in strength until the reversal point of the shadow is found. This manner of increasing in *hypermetropia* and of decreasing in *myopia* is called the *amplifying* method.

Overcorrecting in *hyperopic* cases and undercorrecting in *myopic* ones have been termed the *fogging* method. And where *ocular skiametry* is performed in a *non-toxic* manner this

method of decreasing lens values in *hypermetropia* and of increasing them in *myopia* will often prove of great assistance to an examiner, and especially so if applied in a binocular manner, for then the co-ordinate action of *accommodation* and *convergence* is such as to give the most reliable results. This, of course, includes more particularly those cases where the age of the patient is such as to lead an examiner to fear *spasmodic* muscle action.

In cases of persons fifty years of age or older, wherein *presbyopia* has a tendency to overcome *spasm of accommodation*, then *static skiametry* will frequently be found quite trustworthy, but where the age of the patient is less than fifty years then a method more reliable must be used to determine true refractive conditions.

In the *toxic* application of *static skiametry* it, of course, matters little whether the *amplifying* or *fogging* method is used, for here the *accommodation* is supposed to be in abeyance and the examiner can suit his own convenience in regard to the manner in which he alters his lens quantities. But the *toxic* method has disadvantages along many lines when it is viewed from both scientific and economic standpoints. In its scientific aspect it fails entirely to tell anything about muscle tension at the reading point, leaving this to be estimated and guessed at by the examiner, while this reading point, as is well known, constitutes one of the most important ends for which glasses are adapted. Frequently, too, for distance purposes a medical examiner is led to advise glasses from a *theoretical* instead of a *practical* knowledge of the true conditions present.

All *cycloplegics*, as pointed out before, are of necessity *mydriatics*, and the *mydriasis* they produce constitutes a disturbing factor, causing the pupillary field to become so enlarged as to add to *skiametric* complications and to increase the difficulties of the method.

Viewed from an economic standpoint the *toxic* method tends

toward the needless distress of patients, causes a quite unnecessary waste of valuable time, in waiting for the action of the *cycloplegic*, and takes a foolish chance, even if only a slight one, of risking a possibility of blindness resulting from *glaucoma*.

Every working distance at which *static skiametry* is practiced, whether by *toxic* or *non-toxic* means, really constitutes a method in itself, and for the reason that the nearer a patient's eye an examination is made the more carefully must the appearance of the shadow, as well as other features of the test, be studied. For instance, in an examination made at eighty inches a half-diopter *convex* working lens quantity would have to be placed before the patient's eyes in order to produce *artificial myopia* and focus the parallel rays of light emanating from the *retina* of an *emmetrope*. Here the behavior of the shadow would be much quicker, while its color and intensity would be more pronounced than if the test were made at forty inches, where a one-diopter convex working lens was used.

A test made at forty inches might also prove very satisfactory, while one made at ten inches, using a four-diopter lens, might be anything but satisfactory, even in the same eye. Thus it will be seen that as a student delves deeper into the intricacies of *skiametry* the more complicated does the system seem and the more manifold do its methods appear.

Experience, however, does wonders in developing skill and judgment, so that old examiners, as well as students, profit by constant every-day work, just as old users of the *ophthalmoscope* improve by daily practice with this valuable little instrument for scanning the *ocular fundus*. The truly wise, therefore, will never miss an opportunity to examine a case.

CORROBORATIVE MEASUREMENTS. It is not so very long ago when to possess an *optometer* of simple make, or a modest trial case, seemed to be all that an examiner needed in order to cope with the requirements of his cases. But, thanks

to the progressives, which include patients as well as examiners, that time has gone by and accuracy and attention to detail are now the order of the day in *optometric* practice.

To do high-class work at the present time (and he who does not do it is pretty sure to be left in the race), an optometrist must be thoroughly familiar with the various methods and devices which have received the stamp of approval of those of recognized ability in this field.

At first thought, it would seem as though the trial case ought to be given primary attention, on account of its age, but, logically, it should come last because it offers the nearest approach to an actual pair of glasses, and because, too, it practically gives the only means of determining binocular vision with any degree of satisfaction.

To *ocular skiametry*, however, belongs the first place in the refractive scale, not from its priority of discovery, but rather from a utilitarian standpoint. It is not only the great *pathfinder* that points the way for other work, but it is also the great *verifier* that tells whether the other work is correct or not. In its most approved application it discloses minute opacities of the *cornea* and *crystalline lens*, thereby giving information at once which the *ophthalmoscope* could not locate except, possibly, after a long time-consuming hunt.

It tells of the presence of *astigmatism*, its character and approximate *axis*, and also whether it is complicated with any error requiring the correction of *spherical* lenses.

It shows refractive conditions independent of the patient's age, language or answers, and serves to check carelessness in all persons.

In children it is of invaluable service, and in those whose hearing is faulty it saves much shouting and misunderstanding.

Its use, therefore, comes at both the beginning of an examination and at its end, and if *astigmatism* of considerable amount

is disclosed it is a source of satisfaction, though perhaps not absolutely necessary, to use a *keratometer* and endeavor to *objectively* locate the exact axis of the error. Then following these methods it is well to ascertain, *subjectively* of course, whether vision is in harmony with refraction, if it be found otherwise then the *ophthalmoscope* should be employed to ascertain, if possible, why, and thus enable the optometrist to know whether the case is one calling for glasses, for medical treatment, or for both.

If the vision and the refraction agree in a *monocular* manner, but not in a *binocular* one, then *phorometric* devices are to be called into requisition. Thus it will be seen that in the order of their use *skiametry* is first, *keratometry* second, *trial-case* lenses third, and then, if needed, *ophthalmoscopy* fourth, *phorometry* fifth and *perimetry* sixth.

Three of these methods represent the *objective*, and three the *subjective*, so that practically all of the six methods are interdependent, the only one which might really be dispensed with being the *cornea* measure, and this it not advisable.

In all-round *optometric* work the placing of sole dependence upon one method, one device, or one system, for success, is about as foolish as it would be to place like dependence upon one method, one device, or one system in the practice of any other professional calling, where the conditions are likely to vary in different cases.

Then, too, the use of examination room apparatus, whose only value is to mystify patients and make them believe they are undergoing a thorough scientific examination, is a means hardly calculated to maintain that lasting public confidence which usually contributes to a long and increasing practice. Nor is it wise to idle away a patient's time in needless visual tests merely for the purpose of trying to create favorable impressions regarding professional ability, for there is now enough that is of real value in *optometric* work to gain, with

intelligent use, the confidence of educated as well as uneducated patrons.

To attain the very highest order of practical scientific results should be the well defined aim of those who devote either all or part of their time and ability to the mastery of *physiologic* optics. And as a means to this end the practice of systematically corroborating all ocular measurements will be found to act as a preventive to the making of those mistakes which, when discovered by some other examiner, are so difficult of explanation.

SYSTEMATIC CASE RECORDS. As one of the pronounced aids to successful examination room work, a brief reference will here be made to systematic examinations and the practical assistance to be derived from carefully recording them.

The great value of this troublesome detail can not be emphasized too frequently for, as has been remarked before, *ocular skiametry* is the great refractive pathfinder, and therefore when the path has once been found it is wise to keep it, and keep track of its various windings.

A blank form should be used containing properly named spaces wherein entries can be systematically made, so that nothing of importance may be overlooked in the hurry of busy days. This blank should be large enough to contain on one sheet a complete record of everything pertaining to a case.

This is an age of card indexes, and the makers of these valuable time-savers seem, at last, to appreciate the needs of those who are engaged in *optometric* work, for they now make their cards large enough to meet the optometrist's purposes, as shown by Fig. 58.

This card is five inches wide by eight inches long, and is plain on the back so as to permit of space for entries covering repairing and changes. It is designed in such a manner as to

FIG. 58.

Date _____ 191 ? _____ Occupation _____

Name, _____

Street, _____

City, _____

OBJECTIVE											
		Lids		Cornea		Iris		Lens		Fundus	
Ophthalmoscopic											

Skiatometric	O. D.	Sph.	Sph.	Sph.	Sph.	Cyl.	Axis	Keratometric	Am't.	Axis
	O. S.	$\frac{s}{M}$	$\frac{1}{M}$	$\frac{33}{C}$	$\frac{1}{M}$					

SUBJECTIVE								
Phacometric	O. D.	Sph.	Cyl.	Axis	U. V.	C. V.	Amp.	Presby.
		O. S.						

Prismometric	O. D.	Ad.	Ab.	Sur.	Ex.	Es.	Hyp.	Case History
	O. S.							

PREVIOUS FORMULA								
R=	O. D.	Sph.	Cyl.	Axis	P=	Sph.	Cyl.	Axis
	O. S.							

Ordered by _____ In use _____ years

FACIAL MEASUREMENT			
P. D.	H'ght.	Cr'st.	Base, _____ Ear, _____ Head _____

FORMULA PRESCRIBED									
For R	O. D.	Sph.	Cyl.	Axis	Prism	Base	Lenses	Spg.	Guard
	O. S.							Mtg.	Stud

For Bi-F. add _____ Size of Lens _____ x _____ Segs. _____ x _____ Price, \$ _____

For P	O. D.	Sph.	Cyl.	Axis	Prism	Base	Lenses	Spg.	Guard
	O. S.							Mtg.	Stud

Size of Lens _____ x _____ Price, \$ _____ Fee, \$ _____

Total, \$ _____ Amount Paid, \$ _____ Amount Due, \$ _____

Call _____ Mail _____

Referred by _____ Ex'm'd by _____

No. _____

AUTHOR'S RECORD BLANK.

expedite examinations and to show at a glance whether conditions are usual or unusual. The space for case history while not large will be found ample when taken in connection with the preliminary findings.

Generally speaking, "case history" covers only the symptoms complained of by the patient but, broadly, all findings that serve as an aid to the formation of correct judgment constitute *optometric* case history in its true sense.

The records, both old and new, which are made use of during the week also serve as a kind of day-book and thus in the end really save more labor, from a bookkeeping standpoint, than their use entails.

To describe more completely the uses for which a record blank is intended it can be stated that the age of the patient may be marked in cipher, so that inquisitive persons cannot gratify idle curiosity if the record happens to be left carelessly exposed.

The examination covers "occupation," for it is important to know what kind of work the eyes are to be used for. Then follows the use of the *ophthalmoscope* and a cursory inspection of the *lids, cornea, iris, lens* and *fundus*. As the word *optometric* pertains to eye measuring *in general* it will be seen that eye measuring *in detail* ought, logically, to have its word terminals in *metrics* too, hence this rule has been followed as far as possible in the make-up of this blank.

Skiametric covers both *static* and *dynamic* methods, space being given for one-third, one and six-millimeter data. *Keratometric* gives the *corneal* mal-curvatures and *axes*.

Phacometric covers the *subjective* findings made with trial-case lenses. While "U. V." stands for uncorrected vision, and "C. V." for corrected. "Amp" for "*amplimetric*" is the same as *amplitude of accommodation*, only shorter. If it is desired to have the blank embrace further tests, then the word *perimetric* could be used to cover the use of the *perimeter*, and

under *prismometric* could be recorded the tendencies toward deviation of the *extrinsic* muscles, called *phorometric*, while under a classification of "*tropometric*" could be shown the actual deviations. *Kratometric* pertains to strength, and so would show *duction* tests and exercises, all of which could be expressed in degrees with the exception of the exercises, and the word "over" could call attention to them on the back of the blank where space is ample.

Presbymetric or, literally, old-man measuring, is the same as *presbyopic*, or old-man vision. The prefix *ocular*, of course, connects the eye with all of these measurements.

"Previous formula" and the rest of the blank needs no translation, unless it is to call attention to "segs" for *segments*, in bi-focal work, and to add that under "lenses" can be noted the *regular*, *toric*, *tinted* and *fused* kinds. First quality lenses could be termed *centex*, and second quality could be designated as *ordigrad*.

For purposes of explanation, let it be supposed that an examiner is fallible and *does* err in judgment, and that a patient returns and has a slight change made. This is duly recorded on the back of the blank as well as the fact that no charge was made for this change.

In the course of a few months, perhaps, a new "O. D." is supplied, which, with its price, is also recorded, and thus the blank will last for years, for whenever the patient calls the blank can be taken into the examination room and made to serve as a complete "book of the play."

When *skiametric* examinations are recorded they seldom have to be repeated in return cases. It is only the *subjective* tests, and the variations of judgment that, ordinarily, require attention.

Therefore when it is stated that systematic ocular examination records are very valuable, from a practical standpoint, this statement might go further and class them along with examina-

tion rooms and claim both as absolutely essential in this day and age, when a pronounced success in optometry is only achieved by paying strict attention to every detail of method, place and device.

RESOURCEFULNESS. When to rely on a patient's "Yes" or "No," and when not to, requires no small amount of knowledge of human nature, as well as ability as a cross-questioner. Of course *ocular skiametry* and other *objective* means place an examiner in a position largely independent of a patient's answers or intelligence, yet it is always a source of satisfaction to have one method corroborate another, since there are many ways in which to be wrong and only one way in which to be exactly right. With so-called *regular* conditions skiametrists are likely to have little trouble, but the *irregular* kind frequently call for considerable versatility on the part of an examiner in order to extricate himself from a refractive corner, so to speak.

To illustrate this, a case of *nystagmus* once presented itself which had been seen by a half-dozen able specialists. The age of the patient was twenty years, and the glasses in use were one-diopter *concave sphericals* for both eyes, which gave an acuity of vision equal to about ten two-hundredths.

The use of the *skiascope* showed the presence of *myopic astigmatia, with the rule*, but the spasmodic action of the muscles precluded the ascertaining of the amount. By recourse to the *keratometer* and by engaging the patient in a long conversation regarding daily work, in order to quiet the *spasm*, it became possible to locate a *corneal mal-curvature* of about five diopters. The use of the mirror again showed the absence of any error at right angles, and glasses of four diopters *concave cylindric* at axis 180 after thirty days' use increased vision to a little better than twenty one-hundredths.

When it is borne in mind that this case had been under care-

ful observation for twelve years, and that no expense had been spared in consulting the most eminent specialists, the joy of the patient over the results achieved can readily be imagined.

A haphazard trial of test lenses might have resulted in a clue which could have been followed up satisfactorily, perhaps, but this less certain method frequently leads an examiner astray through the patient's failure to appreciate and give an encouraging answer to a partial correction.

In the refractive examination of the eyes of children, deaf persons, mutes and illiterates, *ocular skiametry* offers about the only reliable means for independently determining the kind and strength of proper glasses.

In this same category might be included those persons who are only partially deaf, and who fail to respond to all questions asked them. Also those persons who do not speak the same language the examiner does, and careless persons who sometimes prefer to joke and thus unconsciously cause an examiner to become careless himself. Then there are the ultra careful persons whose answers are about as misleading as though they too were careless.

All of these and many others tend to show the value of *ocular skiametry*, for success must be achieved, no matter what the obstacles are, as an examiner can ill afford to endanger his reputation through poor work.

MECHANICAL MYDRIASIS. As pointed out by other writers, the production of *mydriasis* by temporary paralysis serves to uncover *corneal zones* which add much to the confusion of an operator in making his measurements by the shadow test, owing to the refractive variations found from center of *cornea* to circumference of *pupil*.

Then, too, *habits*, which are formed through the efforts of nature in trying to adapt herself to the best conditions possible, are no doubt responsible for the difference in size of

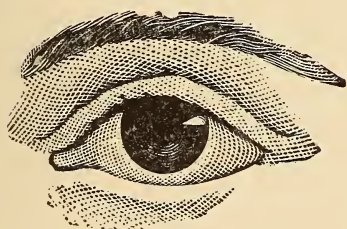
ocular pupils where the ages and refractive errors of patients are the same. Skiametrists will therefore find that *mydriasis* produced by magnifying will give them better results than where the constricting muscles of the pupil are paralyzed by toxicants, and the reason for this lies in the fact that through magnification only that portion of the *cornea* which is limited to the size of the *pupil* is measured, thus avoiding the *peripheral zones*.

Enlargement by magnification would seemingly mean an increase in size at the expense of definition. Let it be considered, then, whether this is really so or not. The word "definition," as used in optics, means the power of a lens to give an image of anything, or part, so as to clearly distinguish it from its surroundings. But this is perhaps misleading, as experienced microscopists say that a lens of low power often works better than one of high power, because with a low-power lens a better general idea may be had of the object, even at the expense of size, than if it were viewed through a high-power lens.

It might be reasoned from this, therefore, that it applied to the magnifying of the *retinal* shadow. But here comes the examiner's own vision and the law of a five-minute angle governing its acuity. If he operated at a much nearer point than forty inches, any increase in size of shadow, without corresponding increase in substance of which it is composed, might interfere with the sharpness of demarcation caused by magnifying. But many ocular pupils are so small that the *retinal* shadow gives a visual angle of less than one-half, perhaps, of what it should at forty inches away, and so, when the pupil is magnified to several times its original size, the increase in visual angle more than compensates for the decrease in sharpness of outline. Hence this explanation to theoretically account for that which those who use this method learn to be a fact from actual experience.

A simple experiment can be tried which will serve to emphasize the superiority of this magnification principle. If a patient will hold a convex seven-diopter *spherical* lens two inches in front of his eye and let an examiner compare the sharpness of outline of the union between the *iris* and the *sclerotic* from a distance of forty inches away, and then determine which one of the patient's two eyes is the easiest to see, the magnified or the unmagnified one, the difference will be very apparent, and the larger *iris* will seem to lose little if any of its color or intensity on account of magnification. Figs.

FIG. 59.



REGULAR SIZE PUPIL.

FIG. 60.



AREA OF MAGNIFIED PUPIL.

59 and 60 illustrate the relative size between an average pupil and one enlarged three diameters.

The working distance at which an examiner operates will, of course, affect the magnifying power of whatever lenses may be used, but as a rule this magnifying principle will be seen to take care of itself, for in high degrees of *hypermetropia*, where small pupils are apt to be found, the enlargement caused by the lenses in an instrument constructed on mobile principles will usually be ample for all practical purposes.

Where an instrument is not available, a three-cell trial frame can sometimes be used to advantage, especially when the first and third cells are widely separated. In this case place

a minus 20. D. *spheric* lens in the cell next to the patient, and a plus 16. D. *spheric* lens in the cell next to the examiner, the plus 16. D. lens acting as an appreciable magnifier, and its distance from the minus 20. D. lens will be sufficient to neutralize the 4. D. difference in the strength of the lenses. In this way small pupils can often be doubled in area, which helps greatly when other conditions are poor.

Another way is to use a strong *concave spheric* in a regular trial frame and then hold a weak *convex* lens much farther away. The manner being the same as the strong *convex* lens is held in practising *indirect ophthalmoscopy*.

CHAPTER X.

VALUE OF INSTRUMENTS IN PRACTISING OPTOMETRY.—
MOBILE AND UNIT LENS SYSTEMS.—VARIOUS INSTRUMENTS USED IN SKIOMETRY, WITH DESCRIPTIONS OF THEIR MECHANICAL CONSTRUCTION.

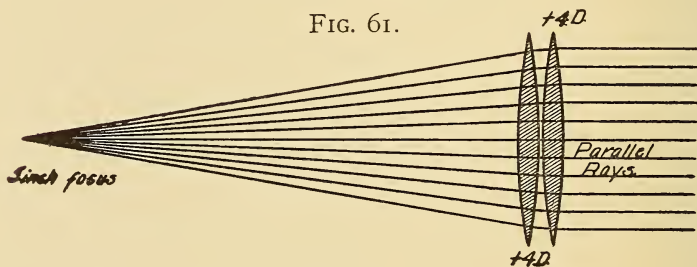
VALUE OF INSTRUMENTS. The value of instruments in optometric practice can hardly be overestimated, if accuracy, encouragement and speed are to be considered. For while it is true that all optometrists should be so trained as to be able to do their work with crude apparatus, it is also true that they should be educated in the expert handling of devices which tend to make their work more efficient.

All optometric instruments are at best only tools which depend for their usefulness upon the intelligence of those who handle them. The confession, therefore, of inability to use an instrument is tantamount to a confession of incompetency. Some tools and instruments have greater scientific and economic value than others have, and it frequently happens that the instrument or device whose manipulation is easiest to acquire is not always the best one to use. The inexperienced should be influenced by the experienced in the selection of their examination room armament, provided this experience is adequate and its possessor does not belong to that class of examiners who get into ruts and are incapable of extricating themselves, no matter what the true value of the optometric inducement may be.

In the selection of instruments there is one point which usually commends itself to those who have had opportunities of using various kinds, and that is the superiority of mobile

action over the unit action of lenses. This so-called "unit" in the *ophthalmic* lenses in general use to-day is termed "one diopter," but in reality the unit comes nearer to being an eighth of a diopter, as lenses are now employed, these small quantities acting as steps whereby the *accommodation* of an eye is compelled to jump from one adjustment to another.

To overcome this jumping principle in the measuring of *convergence* the "Risley" *mobile prism* was invented. This *prism* arrangement serves to change these abrupt degree-jumps into a sort of sliding motion, thereby permitting a gradual increase or decrease in the light deviation, and resembling the action of a wedge while being made to lift a weight.



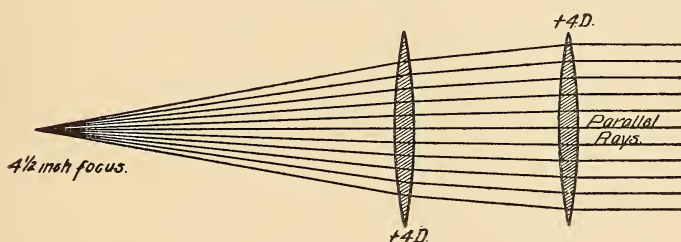
REFRACTION BY LENSES PLACED CLOSE TOGETHER.

MOBILE LENS ACTION. With both *cylindric* and *spheric* lenses this sliding principle can be imitated. Thus two *convex* lenses of four diopters each when placed close together on their optical axes give a combined refraction of eight diopters, with a focal power equal to five inches. Separate these two lenses two inches and their combined action will represent nine diopters of refraction, having a focal distance of four and a half inches. The increasing or decreasing of the distance between any series of lenses on their optical axes serves to produce a *mobile* effect similar to the action of the *crystalline lens* in a living eye, thus enabling *accommodation* to be given

the same character of assistance as that accorded to *convergence* by a *mobile prism*. Figs. 61 and 62 will make this point plainer.

That this *mobile* action is a valuable factor in dealing with stubborn cases of *spasm* is not difficult to perceive, any more than it is difficult to note the fact that the raising or lowering of a heavy safe by sliding on a plane is easier than it would be by using a series of steps. The evenness of the sliding motion serves to induce an accuracy of action that can hardly be imitated by a motion which might, perhaps, be best described as by *jumps* or by *leaps*.

FIG. 62.



REFRACTION BY LENSES WHEN SEPARATED.

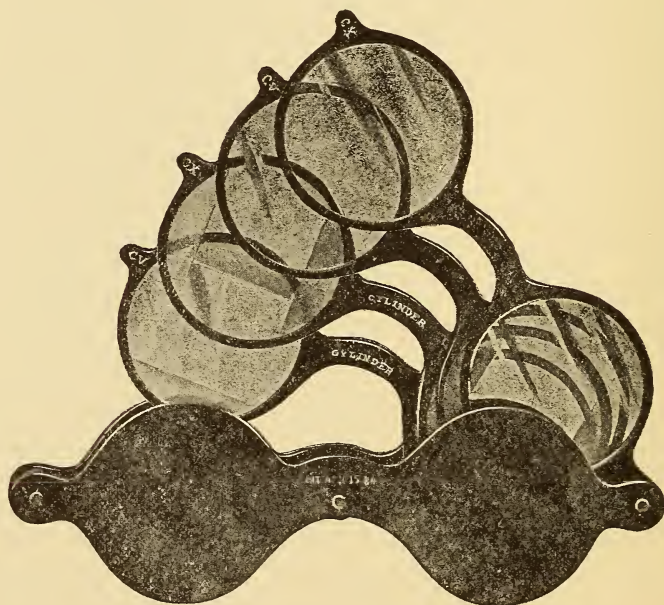
An eye is often considered as having an error equal to one and three-quarters diopters, whereas, the true error may really be one and five-eighths diopters or one and seven-eighths, the one and three-quarters merely indicating an approximate correction. In many cases this would undoubtedly be near enough, but in others a knowledge of the exact refraction is often of importance. Therefore, where a *mobile* lens system is employed there is a greater tendency toward precision than where *lens units* are relied upon.

Then too, the relaxation of *accommodation* will be found much easier with a *mobile* lens system than it will be with a *unit* system, for in reality the *mobile* practically amounts to

the measuring of a living eye by means of an artificial one possessing similar refractive powers of adjustment.

The invention of a single *mobile* lens capable of adaptation to the needs of mankind would undoubtedly prove a great boon, but until such an invention appears reliance will have to be placed upon a series of lenses arranged for the accomplishment of similar purposes.

FIG. 63.



KING'S BINOCULAR HAND TRIAL SET.

UNIT LENS ACTION. There is one form of the step-like arrangement of lenses that will be found exceedingly valuable in corroborative work, and that is in the old-fashioned metal or hard rubber device illustrated by Fig. 63.

There should be four pairs of *plus* and *minus*, *half* and *quarter*-diopter *spheric* lenses mounted so they can be used in either a *monocular* or *binocular* manner. This device can be employed both *objectively* and *subjectively*, either for near or distant tests, and can be held by the examiner or by the patient. Its convenience in the addition or removal of weak lens power serves to determine *accommodative* action, and frequently gives that slight fog to vision which enables both patient and examiner to easily differentiate small quantities of *astigmatia*.

In the final study of a case, after the correcting lenses are in position, an examiner will find the use of lenses mounted in pairs, such as shown in Fig. 63, and placed in front of the trial frame, to be an easy way of obtaining those little niceties in refractive adjustment which contribute so much toward the complete visual comfort and satisfaction of a patient, and which also make one examiner's work *just a little better* than another's.

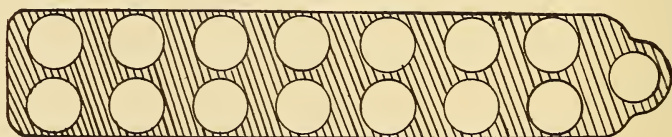
VARIOUS INSTRUMENTS USED IN SKIAMETRY.
Skiametry is somewhat similar to *indirect ophthalmoscopy*, inasmuch as an operator is obliged to do several things at one time. After shadow testing had been improved and brought to a state approaching practical usefulness by men like Cuignet, Parent, and others, it was found that its application entailed such frequent changing of lenses as to discourage its common use.

The first effort of importance along the line of labor-saving devices for *skiametric* work was the lens rack, or hand *skiameter*, to which the name of Würdemann is frequently attached, although its invention is claimed by a large number of others.

Fig. 64 illustrates the constructive principle of this instrument and, as will be seen, it consists of a series of *plus* and *minus spheric* lenses mounted in such a manner as to permit of the patient holding them before his eyes and moving the lenses from one strength to another, at the request of the examiner.

Inasmuch as it proves a saving of time and labor, this device is a decided improvement over the use of single lenses placed in a trial frame. Among the drawbacks to its use, however, will be found the stupidity and carelessness of patients, who frequently permit the lenses to rest at angles which interfere with their correct refraction and thus necessitate a constant readjustment of the rack by the examiner. Then, too, owing to this same stupidity and carelessness, a patient will often allow the lenses to come in contact with the skin on the forehead, eyelids or cheeks, and thereby soil the lenses so they become unfit for use until after they have been cleaned.

FIG. 64.



SKIAMETRIC LENS RACK OF WÜRDEMANN.

Quite a number of modifications of the Würdemann principle have been produced, but the drawbacks just mentioned seem common to them all.

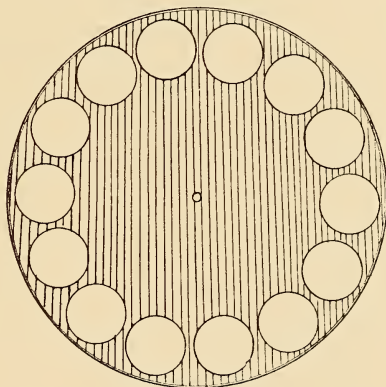
The Crain *disc* and the Standart *annular* ring of lenses are both popular: the first named being on a stand for use on a table, while the last named is held by a wall bracket. Fig. 65 shows the large disc of lenses used in the Crain device.

The lenses of the disc can be either *spheric* or *cylindric* as the examiner chooses. The disc can also be revolved by the examiner or by the patient at the former's request. These discs, or batteries of lenses, are something of an improvement on the hand rack of Würdemann, inasmuch as they hold the lenses in such a position as to permit of no material twisting or disturbance to their principal axes. The reliance on the patient to

turn the discs and the necessity for troublesome adjustments as to height, together with the annoyances incident to keeping the head of the patient so situated that the eyes will always be in proper position, constitute some of the reasons why these devices have not been in greater demand.

The Standart "*Umbrameter*" is an instrument thoroughly vouched for by its inventor, who is one of the foremost optometrists of America; Fig. 66 shows its general construction.

FIG. 65.



LENS DISC USED BY CRAIN AND OTHERS.

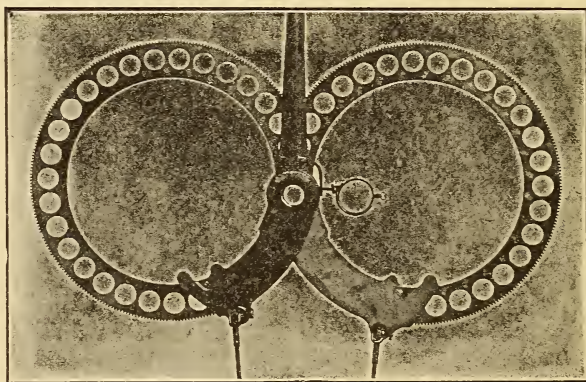
The makers of this device tell of its merits in the following words:

"Time is a great element with a busy refractionist. A patient in the chair and a half dozen waiting means that unless the operator is rapid in his work, some of the waiting ones will get tired and go out.

"The Standart *Umbrameter* is designed to save time, to contribute to accuracy in results and impress the client with the skill and efficient equipment of the up-to-date refractionist.

"Combining accurately all spheres from one-quarter to six and one-half dioptrics by quarters, and from six and one-half to nine dioptrics by halves, and all cylinders from one-quarter dioptic to seven and three-quarters dioptic by quarter dioptics, set at any axis, with their manipulation easily accomplished at one meter distant, makes this instrument the most perfect adjunct of the retinoscope ever devised.

FIG. 66.



STANDART'S UMBRAMETER.

"A little practice will make it an indispensable addition to the *instrumentarium* of the operating room. It will save its cost in a short time by increasing sales during the busy hours of the day, rendering changes less liable to be necessary and saving that valuable element—time.

"The operation is simple: Loosen the thumb screws on rod pinions and grasp the hanging upright bar with the right hand, then with the left hand turn geared lens ring around until 0 is shown in the number aperture on lower part of the frame; this is the zero point.

"Direct the patient to assume an easy position and to look towards some object 15 or 20 feet away pinned upon the wall so that the line of patient's vision will just come over the top of operator's head while seated 40 inches away facing patient.

"Adjust the instrument up or down, turning it sideways and tipping the annular rings up or down to bring it to the proper position before the patient's eye.

"From the trial set slip under springs on the back of the eye hole a spherical convex lens of sufficient power to create a positive pseudo myopia. If the case is one of known myopia of over 1.00 D., leave the supplemental lens out, or if it is discovered after a little examination that it is a case of true myopia or myopic astigmatism, then this supplemental lens may be removed, if desired.

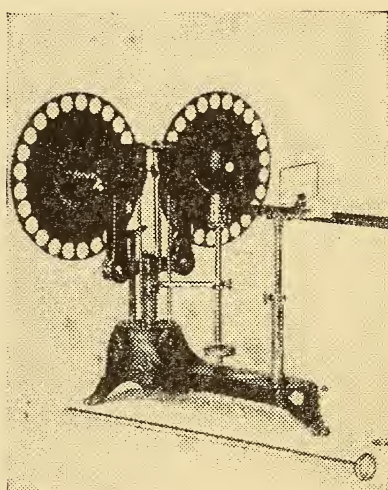
"This is the fogging system applied to skiascopy, the most accurate yet discovered. There is a diversity of opinion as to the relative value of plano or concave mirrors. We suggest for use the concave of about 1 dioptric curve and with a hole not more than two millimeters in diameter.

"Seated on a revolving stool that may be raised or lowered one meter (40 inches), from patient, the length of the rods, and a light, preferably an Argand burner with a flame about 1 to 1½ inches high, over the head of the patient and slightly back, direct the patient to look over the top of your head at some object on the wall.

"In the right hand is held the mirror and in the left one of the rod handles, the other rod being suspended therefrom by an S link. Secure a clear fundus reflex through the aperture provided for the patient to look through, and then turn spheres until one medium stands still. If there is then astigmatism present, calculate the axis, then adjust the annular ring containing cylinders so that the mark on scale shows the meridian determined and then proceed as before until that meridian is neutralized. Should the astigmatism appear in the vertical, or

its approximations, use the white scale revolving the lenses downward bringing the cyls, setting vertically on the instrument, downward. Should the astigmatism appear in the horizontal, or its approximations, then use the red scale revolving lenses set in the instrument horizontally upward into position.

FIG. 67.



THE MERIDEN OCULOMETROSCOPE.

"The ring containing spheres may be turned down or up on its axis to suit convenience and comfort of the patient without affecting the axis of the cylinders."

The "*Oculometroscope*," made by the Meriden Optical Manufacturing Company, is shown in Fig. 67.

This is perhaps the latest form of disc instruments. It carries its own lamp and has a turning rod attached to each disc whereby an examiner is enabled to change lenses without

altering his position when operating at a distance of forty or more inches away.

The manufacturers of this instrument set forth its use, as follows:

"With this instrument you can measure the far point, near point, amplitude of accommodation, hypermetropia, myopia, presbyopia and astigmatism. Also the muscular insufficiencies by using a prism from your trial case. It can be used for both objective and subjective tests.

"The Oculometroscope is a great time saver in using the fogging system, and in retinoscopy by the static, dynamic or fogging methods. With it you can locate the axis for cylinders without the use of a chart.

"As a time saver in retinoscopy this instrument is unexcelled. You can save the time usually lost in changing lenses in trial frame and in finding the reflexes, time after time, and also avoid the danger of small errors from not getting the one meter distance every time.

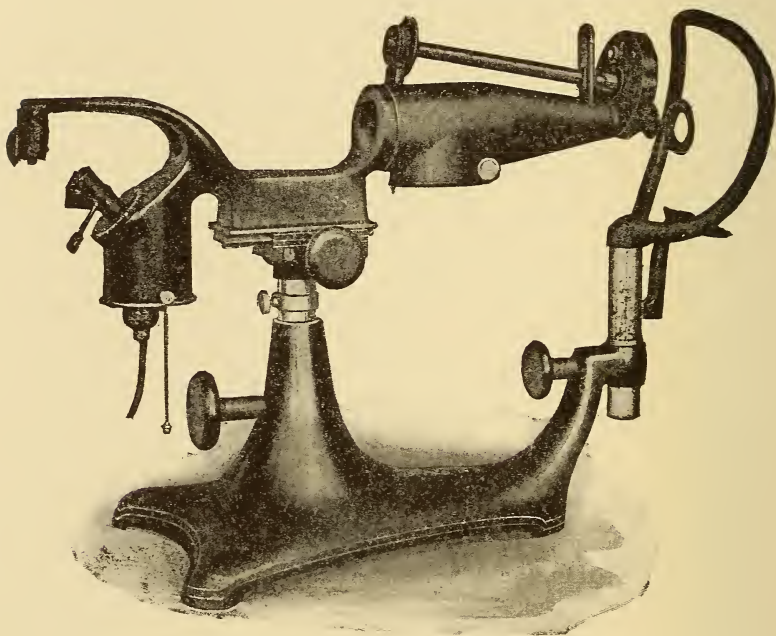
"Seat the patient comfortably before the instrument with chin in the rest and eyes looking through the open disc. Care must be taken to have the centers of the discs properly adjusted for the patient's p. d. Have the patient look into the distance, relaxing the eye as much as possible. Rotate the lens discs by rod until plus 1.00 appears in the indicators.

"Turn on the light, and with the plane mirror at the end of the graduated rod (which is exactly one metre from the patient's eyes) proceed to examine the eyes with the mirror. You do not have to move mirror from position to change lenses in front of patient's eyes, and you are always sure of maintaining a one-metre distance.

"This means a great saving of time usually lost in changing lenses in trial frame, and finding reflex, time after time, also lessens the danger of small errors from not getting the one-metre distance every time."

The latest model of what is known as the "Geneva Retinoscope," manufactured by the Geneva Optical Co., of Chicago, is shown in Fig. 68.

FIG. 68.



THE "GENEVA" RETINOSCOPE.

The makers put forth the following claims of merit for this instrument, which also combines an *indirect ophthalmoscopic* adjustment.

"This instrument makes use of the direct method of retinoscopy, the most valuable of methods for testing the refraction of the eye, because (1) it is an objective test and requires no catechism of the patient, and (2) because of its wonderful

exactness. But the instrument offers special advantages to the retinoscopist above those possibly obtainable by the hand method. These are chiefly as follows:

"1st. The instrument introduces no new principle, but simplifies the general method of skiascopy as practiced in the dark room with a plane mirror. The same rules that govern in the hand method govern also in the use of the instrument, and those who are experienced in the test have nothing to unlearn.

"2d. The instrument may be operated in a light, airy room or the regular office for refraction work. This enables the operator to combine with it the fogging method for reducing ciliary spasm. This combination is impossible in dark room skiascopy, for darkening the room to brighten the reflex obscures the distant object by which the accommodation is properly fogged.

"3d. The mirror is so fixed that it may be tilted true to any given meridian and so arranged that it may be rotated to any meridian and remain stationary in that meridian as long as desired. This gives a far greater degree of accuracy in locating the two principal meridians in an astigmatic eye than is possible with an ordinary hand retinoscope, as used in the method hitherto practiced.

"4th. The light, mirror, patient's eye and observer's eye are always in their exact relative positions, and there is no time wasted, therefore, in finding the patient's eye or keeping it in view when found. Moreover, having the distances all fixed once and for all, the operator does not need to keep them perpetually in mind or think of them at all. He can devote his whole attention to watching the movements of the reflex and shadow and operating the lens discs to get the result he requires.

"5th. There are no deductions or additions to be made when the right lens is found, for the distances are all neutralized to infinity with plus lenses fixed in the instrument. The point of reversal of an emmetropic observed eye is always about one inch back of the mirror, or where the cornea of the observer's eye will be when the best view of the pupil is obtained.

"6th. There are arranged in the instrument two large rotating discs in which are fixed batteries of plus and minus lenses. These discs may be so rotated as to bring any desired plus or minus lens before the patient's eye. This obviates the necessity of reaching forward to change the lenses from the trial case during the examination—one of the most inconvenient features of open retinoscopy, as generally practiced.

"7th. The lights used may be changed in one minute from oil to gas or electric, as they are interchangeable."

The De Zeng Combined Optometer, Phorometer and Skiometer, manufactured by the De Zeng-Standard Co., Camden, N. J., is another late invention designed for use in both *objective* and *subjective* optometry, also for muscle measuring and exercising as well.

Fig. 69 shows the general appearance of the head of this instrument, which can be mounted either on a bracket or on a stand.

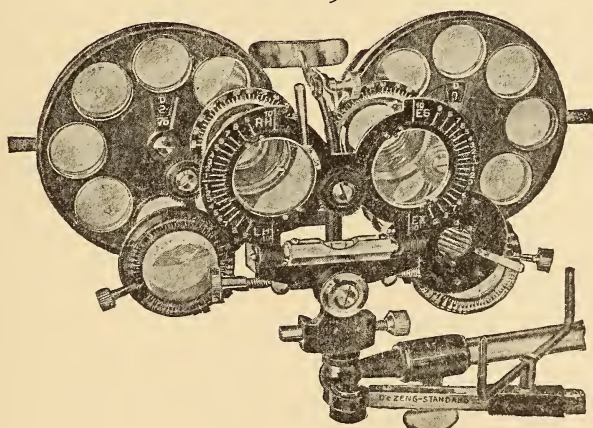
The manufacturers set forth the merits of this comprehensive device in the following claims:

"This new instrument is a perfect combination of our well known Phoro-Optometer and a binocular quadruple series of plus and minus spherical lenses mounted in light disk form. It is exceedingly compact and complete, is unusually light, well finished and is the best all around instrument ever offered for Objective and Subjective Refraction and Muscle Work.

"The lenses are all one inch in diameter, are accurately

ground and centered, and may be brought into operative position separately or in combination as desired. The first disk facing the operator contains 0, .25, .50, .75, 1.00, 1.25, 1.50 and 1.75 in plus spheres; the second disk carries the same numbers in minus spheres, the third disk holds the first series of auxiliary numbers, and by a partial rotation outward from zero, 2.00, 4.00 and 6.00 in plus are obtained, while an inward movement from zero gives 2.00, 4.00, 6.00 and 8.00 in the

FIG. 69.



DE ZENG'S OPTOMETER, PHOROMETER AND SKIAMETER.

minus. The fourth disk contains the second series of auxiliary numbers, and by a partial rotation of the disk downward from the horizontal position of the Controlling Arm, which is located at zero, plus .12, 8.00 and 1.50 are obtained, while an upward movement from zero gives minus .12, 10.00 and blank. The plus 1.50 lens is for use in Retinoscopy at a 26-inch working distance, which is within arm's reach of the Instrument. By combining the contents of the first disk with the positive auxiliary numbers in the third and fourth disks, all of the

positive equivalents from .12 to 7.87 inclusive are obtainable in eighths, and from .25 to 15.75 inclusive in quarters. The negative equivalents are likewise obtained by employing the second disk in conjunction with the minus auxiliaries carried by the third and fourth disks, but in the minus numbers the range is extended to 9.87 in eighths and to 19.75 in quarters."

With the exception of the author's instrument which, as will presently be seen, is a radical departure in almost every way from those just referred to, this completes the list, although there are still quite a number of other instruments which embrace the principles here shown.

Jackson in his valuable book on Skiascopy, in speaking of the use of disc lenses (page 109) says: "*But even in this case, the fact that there is a complete break between the appearances represented by one lens, and the appearances present by the use of the lens next stronger or weaker, makes the information obtained less valuable and satisfactory than that derived from the movement of the surgeon's eye from one position to another, which allows him to watch the different appearances of light and shade as they pass gradually into each other.*" This "movement of the surgeon's eye" to which he refers has since been practically duplicated by making the lens action *mobile* instead of *fixed*, thus securing superior results with less effort.

From the instrument of Crain to that of the Geneva it may be observed that the proper adjustment of the patient's head by means of chin rests, etc., is an important item, and, with the exception of the *oculometroscope* type of instrument they all require separate adjustment for each eye. Besides, not one of them is arranged for magnifying the patient's pupil, no matter how small it may be nor how great the difficulty of accurately noting the action of its shadow.

All of the disc type of instruments are designed to work at one fixed distance, no latitude being allowed unless they

are operated in an awkward manner, and this of course limits their use to the *static* method only, barring out the *dynamic*, which of the two is really the more valuable. Therefore, all *monocular* testing instruments are of little service in thorough *skiametric* work.

Würdemann's device is, like the use of trial lenses, most excellent in theory, but in practice its shortcomings seem to be many. In the practical workings of all disc devices their use usually proves of considerable assistance to an examiner, especially when the disc can be controlled by rods, but all disc instruments, it is feared, will eventually be relegated to the company of the many other *optometric* devices which have been weighed in the balance and found wanting. However, it is for others to judge of this after they have informed themselves regarding the advantages gained by the use of the next instrument to which attention is here called.

THE AUTHOR'S SKIAMETER. This little device, among its other features, was designed to accomplish a purpose similar to that of the various disc contrivances in overcoming the necessity for having examiners change position every time a lens needed changing. Like Würdemann's device, too, it was designed as a hand instrument, so as to make the adjustments rapid and easy, but unlike Würdemann's rack, it was arranged to be so placed that its position should be as secure as that of a trial frame.

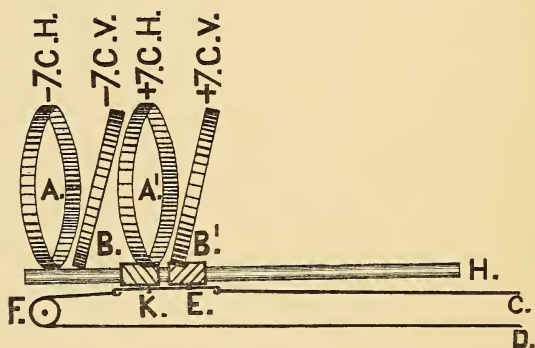
Enlargement of ocular pupils was sought for and achieved, together with *mobile* lens action. Variety in methods of operating was not so much a first consideration as it was an afterthought. The construction of the instrument, however, needed very little alteration after *dynamic skiametry* was developed, although the addition of this method to the value of the instrument has been found too great to be estimated by figures.

Binocular action was also an original feature; then sim-

plicity; not only simplicity of construction and action, but simplicity of operation. Fig. 70 shows the mechanical arrangement of the instrument and the manner of the adjustment of its lens system.

Two *convex* and two *concave* cylindric lenses of seven diopters each are mounted in cells A and B, and A and B prime, with their axes at right angles to each other, each lens being slightly inclined from the perpendicular on its meridional

FIG. 70.



CONSTRUCTIVE PRINCIPLE OF AUTHOR'S SKIAMETER.

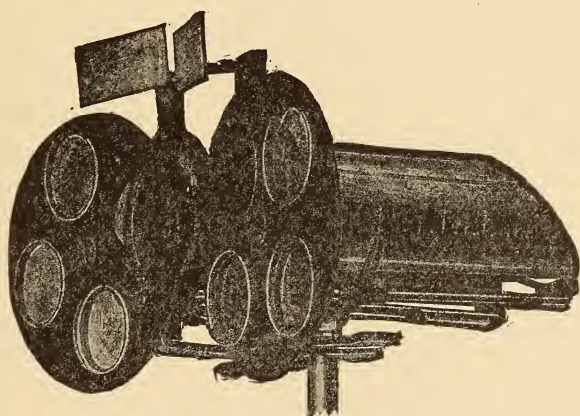
axis. The two *concave* lenses are stationary while the two *convex* ones are made movable. The cells of the latter slide on rod H, being controlled by a doubled cord C, D, thirty-six inches in length, this cord passing over pulley F. The cord's length being always the same, an operator has merely to turn his hand at the wrist in order to obtain full control of the refractive changes of the instrument.

In the use of *convex* cylindric lenses it was found that by placing each cell on a sliding block, such as shown by K and E, and by then using a hook the operator could unfasten

them while working at a distance by merely moving his hand a few inches to one side. The *cylindric* lenses used in this way could also be made to serve a double purpose; for when used together they acted as a single *spheric* lens does, but when used singly, or unlocked, they acted as simple *cylinders*.

Another valuable principle was also discovered and made use of. It was found that as the *plus cylinders*, A and B prime, were moved away from the *minus cylinders*, A and B,

FIG. 71.



AUTHOR'S SKIAMETER, WITHOUT BASE.

any object, such as a patient's eye, when placed close up to the *concave* lenses, would be magnified by the *convex* ones, just as though a plain seven-diopter *convex spheric* lens had been used, this magnification taking place without causing the least interference in the refraction of the four lenses while they were being used as a lens series to produce *mobility* of action.

Other attachments comprise a self-adjusting brow rest to give the instrument stability, a handle, a base and a means for separating the two tubes. The large holes now in the top of

the tubes of the latest model instrument facilitate the cleaning of the lenses, whose cells are all attached to blocks on the slide rods. The *minus cylindric* lenses are secured in position by a set screw in the block holding cell B.

Fig. 71 shows the instrument complete, with its auxiliary lens disc containing three *sphericals*, *i. e.*, — 1. — 3. and — 6. D., to be used in converting the instrument from the *static* to the *dynamic* method, also for changing the total refraction from *plus* to *minus*, as occasion demands.

CHAPTER XI.

QUESTIONS AND ANSWERS PERTAINING TO STATIC AND DYNAMIC SKIAMETRY AND CORRELATED SUBJECTS, WITH PERTINENT REMARKS EMPHASIZING THE SALIENT POINTS INVOLVED.

There is perhaps no better way in which to fixedly impress upon the mind of the student the underlying principles governing *ocular skiametry* than to require him to answer a series of questions embracing the salient points involved in the subject. The remarks following each answer given in this chapter, though sometimes a repetition of matter contained in previous chapters, will also serve to emphasize the principal points involved. But to avoid creating any wrong impressions it may be well to preface these questions and answers by calling attention once more to the fact that the subjects are here treated in a purely *theoretic* manner. For instance: If by *dynamic skiametry* the *intrinsic* and *extrinsic* muscles are not in a "1 to 3" relationship then the refractive findings will not be the same as though these muscles maintained this so-called "standard" harmony.

One of the greatest points of merit of *skiametry* is that it always tells the exact truth, even though examiners cannot invariably interpret this aright, but when a shadow moves either *with* or *against* a mirror's movement it indicates that the *conjugate focus* of the *emerging* ray is either *posterior* or *anterior* to the examiner's position of *observation*.

The cause influencing focal length of the emerging rays is quite a different question from that of reading the action of the shadow, for what is known by the names, *latent hyperopia*

and *sub-normal presbyopia*, may be merely a changed relationship between *accommodation* and *convergence* that is peculiar to the case under examination.

Skiametry merely determines the state of the refraction at any given point, the same as *phorometry* can be made to show the co-ordination of the two eyes for any point of *convergence*. With *skiametry*, however, the examiner is largely independent of the patient's reliability, whereas, with *phorometry* it depends entirely upon a patient's replies to set questions which thus form a very uncertain quantity.

In the questions following No. 24 it will be noted that *fixation* is never placed nearer the patient than that of *observation*. Theoretically it ought not to make any difference what relationship these two factors bear to one another, but in practical application it will be found that attempted *fixation* for a point inside of the patient's *punctum proximum* will be productive of very uncertain results until the correction nears the point where *fixation* and *observation* become equal.

Where *fixation* is beyond the point of *observation* then more reliable findings are obtained, but for extreme accuracy of measurement it is necessary that *fixation* and *observation* should be the same, lenses being used for altering the focal length of the *emergent* rays while the examiner remains in a fixed position.

Familiarity with both *ray-value* and *lens-value* methods enable an examiner to cover a much wider range of measurements, also to work with greater speed and to secure data that materially aids in the correct formation of that judgment which predetermines success.

QUESTION No. 1. Reduce and transpose the following formula:

$$\begin{aligned} & - 0.50 \text{ D. S. } \odot + 1. \text{ D. C. axis } 15 \odot + 0.25 \text{ D. S.} \\ & \odot - 0.75 \text{ D. C. axis } 105. \end{aligned}$$

Write the answer three ways.

ANSWER NO. 1.

+ 0.75 D. C. $\ominus$ — 1. D. C. axis 105.

+ 0.75 D. S. $\ominus$ — 1.75 D. C. axis 105.

— 1. D. S. $\ominus$ + 1.75 D. C. axis 15.

REMARKS, NO. 1. The reduction and transposition of lenses belongs properly under *theoretic optics*, but its relation to *skiametry* is so pronounced that unless a student makes himself master of at least one reliable system his progress in shadow-testing will, indeed, be difficult.

The author's system of converting all lens values into *cylindric equivalents* and then reconstructing these into desired combinations will give the best forms for the purposes needed and will be found one of the simplest ways of dealing with this complex problem.

By "best forms," it may be added, that in this age of attention to details, it frequently happens that an examiner desires to write his formula so as to obtain a *meniscus* effect in the completed lens, or else he may prefer to so combine his *bi-focals* that the *segment* will always be on the inside of the lens. The form of reduction and transposition described herein makes this possible, hence its importance to the student.

QUESTION NO. 2. With a *schematic eye* set at *emmetropia* and having a + 0.75 D. S. lens before it, how many inches away will the *skiametric reversal* point be?

ANSWER NO. 2. Fifty-three inches.

REMARKS, NO. 2. This is a case of simple *artificial myopia*. In the living eye, however, if the patient had unconsciously looked at any object within *infinity*, say at fifteen feet away, then *accommodative myopia* would be a factor, and the *total myopia* present would be 1. D., making the point of *reversal* at forty inches instead of at fifty-three.

Twenty feet is usually considered as *infinity* in practical optometry, but for real accurate measurements this classification will be found untrustworthy, as a lens of 0.12 D. has a focal length of over twenty-six feet, and in these days formulas calling for 0.12 D. lens-power are not uncommon.

QUESTION No. 3. With a *schematic eye* set for 1. D. of *myopia*, and having a lens — 1. D. C. axis 90 before it, how far away will the *skiametric* point of *reversal* be in the *vertical* meridian?

ANSWER No. 3. Forty inches.

REMARKS, No. 3. It is well known that in an *emmetropic* eye a plus lens held before it creates *myopia*. If the lens is minus, however, then the *artificial* error is *hyperopia*. And if the lenses used are *spherics* then the error is in all meridians, but if *cylindrics* are used then the error is only in the meridian at right angles to the axis of the lens employed.

In question No. 3 the required *myopia* for forty inches working distance is obtained by slightly lengthening the *schematic eye*, and thus what might be considered as *true myopia* is a factor.

The use of a — 1. D. C. lens, axis *vertical*, would serve to neutralize this *true myopia* in the *horizontal* meridian, thereby causing the rays to emerge *parallel*, but the rays in the *vertical*, not having been interfered with, continue to *converge* to a point 1. D., or forty inches away.

QUESTION No. 4. With a *schematic eye* set for 1. D. of *myopia*, what lenses should be added to artificially produce a *mixed astigmatic* error equal to — 1.25 D. S. $\subset$ + 2. D. C. axis 45?

ANSWER No. 4.

+ 1.25 D. S. $\ominus$ — 2. D. C. axis 45 or — 0.75 D. S.
 $\ominus$ + 2. D. C. axis 135.

REMARKS, No. 4. As *myopia* is produced with a *plus* lens and *hyperopia* with a *minus* one then all that is required in the above case is to use lenses of the same strength but opposite kind, and if for any reason these lenses are not available then the second formula, given in the answer, can be made use of, this being obtained by transposition.

In a living eye the *artificial*, or “working,” *myopia* would have to be produced by a + 1. D. S. lens, and then this quantity would have to be taken into consideration in the final analysis. But with *schematic eyes* the *artificial myopia* can be made into *true myopia* by simple adjustment in length, so for purpose of practice work the question of “working quantity” can be temporarily eliminated.

QUESTION No. 5. What is the difference between *tonic* and *clonic* spasm?

ANSWER No. 5. *Tonic spasm* is a persistent, involuntary contraction of a muscle, whereas *clonic spasm* is an intermittent contraction.

REMARKS, No. 5. It would seem to matter very little to an examiner what the character of the *spasm* was that confronted him if it was not for the theoretic side of his work. *Tonic spasms* are met most frequently in *hyperopic* cases, and *clonic* in *myopic* ones, *habit* forming a marked factor. These two kinds of *spasms*, then, are probably responsible for the frequent overcorrections found in *myopia* and for the undercorrections found in *hyperopia*, therefore all examiners should adopt such methods as will eliminate the influence of these uncertain factors.

QUESTION No. 6. How many degrees of *convergence* does a *hypermetrope* of 2. D. suppress when his *accommodation* is adjusted for *infinity*?

ANSWER No. 6. About six degrees.

REMARKS, No. 6. For ease of comprehension the "1 to 3" relationship between *accommodation* and *convergence* will perhaps be found better than where *meter angles* are used. Thus, in question No. 6, it is easy to understand that if 2. D. of *accommodation* is used to overcome the *hypermetropia*, then 2 times 3 degrees equals 6, and if binocular *parallelism* is necessary of the correct registration of rays of light from *infinity*, then suppression of *convergence* must be made. The *intrinsic* muscles in this case dictating to the *extrinsic* ones.

QUESTION No. 7. How many diopters of *accommodation* does a *myope* of 2. D. exert when he *converges* to a point calling for 9 degrees?

ANSWER No. 7. One diopter.

REMARKS, No. 7. The reasoning is simple; if 9 degrees of *convergence* call for 3. D. of *accommodation* and 2. D. of *myopia* neutralizes 2. D. of *accommodation*, then the difference between the *accommodation* that *ought* to be used and the *accommodation* that is *not* used gives the amount of *accommodation* that *is* used.

If A owes B \$3, and B owes C \$2, then if C owes A \$2, there is a chance to settle these differences by the payment of only \$1, all of which can be worked out by a little figuring.

QUESTION No. 8. What is the difference between *static* and *dynamic* skiametry?

ANSWER No. 8. "*Static*" skiametry is where fixation is at *infinity*, while "*dynamic*" skiametry is where fixation is *within infinity*.

REMARKS, No. 8. The above definition is probably as short as a technical one can be given. This question is asked so often, however, that perhaps it ought to be answered in a number of ways.

Static skiametry is where *accommodation* is supposed to be relaxed. *Dynamic* skiametry is where it is supposed to be exerted.

The word "supposed" is used because in *static* skiametry *accommodation* is rarely ever fully relaxed, and in *dynamic* skiametry *accommodation* is rarely ever fully exerted, *spasm* in relaxation and *lag* in exertion, are both to be reckoned with.

Static skiametry can be used for determining the patient's easy adjustment of his ocular muscles for distance, while *dynamic skiametry* can be used for determining the easy adjustment of the ocular muscles for reading or near work.

QUESTION No. 9. By *static skiametry* with fixation at *infinity* and observation at 26 inches, what should be the strength of the lens used to create the working, or *artificial*, myopia?

ANSWER No. 9. $+ 1.50$ D. S.

REMARKS, No. 9. At whatever distance an examiner operates in the *static* method he must be careful to know its exact dioptric value. Thus, if his observation is made at 10 inches he must have an *artificial myopia* of 4. D. If at 20 inches then 2. D., and so on.

If, however, he uses a 2. D. working quantity and carelessly makes his observation from a point 18 inches from his patient, then his findings will show an overcorrection of 0.25 D., for 18 inches calls for a lens quantity of $+ 2.25$ D.

QUESTION No. 10. By *static skiametry* if a $+ 2.25$ D. S.

lens in front of an eye causes reversal in all meridians at 40 inches observation, what is the apparent error?

ANSWER No. 10. 1.25 D. of *hyperopia*.

REMARKS, No. 10. The word "apparent" is used here advisedly. A *static* examination made at 40 inches, or any other distance, gives the exact refraction under the existing conditions, but often these "conditions" are based on an adjustment between *accommodation* and *convergence* which gives a refractive finding that is not in harmony with the one found for reading distance, therefore it will be seen that accuracy in judgment calls for measurements made at various distances.

QUESTION No. 11. By *static skiametry*, if a patient has 1. D. of *hyperopia*, where will the point of *reversal* be in all meridians when a + 2.75 D. S. lens is used?

ANSWER No. 11. At twenty-two inches.

REMARKS, No. 11. In this case the patient's error neutralizes, or absorbs, 1. D. S. of the *artificial myopia*, leaving only 1.75 D. remaining.

If the patient's error had been *myopic*, instead of *hyperopic*, then the total would have been an increase instead of a decrease.

Careful attention must always be given to the kind of *myopia* present, whether it is *true* or *artificial*, and then to keep in mind that *hyperopia* neutralizes *myopia*, and that *myopia* does the same for *hyperopia*.

QUESTION No. 12. By *static skiametry* without any lenses on, if *reversal* is found in all meridians at 13 inches from patient's eyes, what is the error?

ANSWER No. 12. 3. D. of *myopia*.

REMARKS, No. 12. It will be seen from the above that one of the easiest ways to estimate *myopia* is by a tape measure in place of lenses. In *hyperopia*, however, the use of lenses is imperative, for it will be borne in mind that *myopia* of some kind, *true*, *artificial* or *accommodative*, must be present in order to make use of the principles of shadow-testing.

QUESTION No. 13. By *static skiametry* if a patient has 1. D. of *myopic astigmia* in the *vertical* meridian, how many inches away will the point of reversal be in the *horizontal* meridian when he uses a + 1. D. S. lens?

ANSWER No. 13. Forty inches.

REMARKS, No. 13. If the student will keep in mind that all eyes must be measured in two meridians, that of greatest and least refraction, the above will resolve itself into a simple case of reduction. The two chief axes are 90 and 180, and the + 1. D. S. lens creates artificial myopia of 1. D. The reduction then is as follows:

<i>Axis 90</i>	<i>Axis 180</i>
+ 1.	+ 1.
	+ 1.
+ 1.	+ 2.

The refraction in the vertical meridian shows a reversal point at 20 inches.

The student must not forget that *minus* neutralizes *plus*, and that *myopia* therefore indicates a plus condition, because it takes minus lenses to counteract it.

QUESTION No. 14. By *static skiametry* at 40 inches *observation*, if a + 1. D. lens causes reversal in the *vertical* meridian

and it takes a $+ 2$. D. to cause *reversal* in the *horizontal*, what is the error?

ANSWER No. 14. $+ 1$. D. C. axis 90.

REMARKS, No. 14. This is a case for transposition.

Axis 90

Axis 180

$+ 2$.

$+ 1$.

and this equals $+ 1$. D. S. $\ominus + 1$. D. C. axis 90. Adding $- 1$. D. S. for the neutralization of the *artificial myopia*, the error then becomes $+ 1$. D. of *hyperopic astigmatism* in the *horizontal* meridian, with the axis in the *vertical*.

Students must be careful not to get axis and error confused, for an eye that measures 52. D. in the *vertical* meridian and 51. D. in the *horizontal* could be made 52. D. in all meridians by the use of a *cylindric* lens of $+ 1$. D. axis *vertical*.

QUESTION No. 15. By *static skiametry*, if a patient has *compound hyperopic astigmatism* that can be neutralized with a lens of $+ 1$. D. S. $\ominus + 1$. D. C. axis 90, where will the points of *reversal* be in the *horizontal* and *vertical* meridians when he uses a $+ 3$. D. S. lens?

ANSWER No. 15. Forty inches in the *horizontal* and twenty inches in the *vertical*.

REMARKS, No. 15. This is another case of reduction. The student remembering that if *myopia* is a *plus* condition then *hyperopia* must be a *minus* one, and on this basis the reduction would be expressed as follows:

Axis 90

Axis 180

$- 1$.

$- 1$.

$- 1$.

$+ 3$.

$+ 3$.

$+ 1$. D.

$+ 2$. D.

Calling the error *plus* and considering the 3. D. lens as *artificial myopia* the reduction could be figured another way and obtain the same results:

<i>Axis 90</i>	<i>Axis 180</i>
+ 1.	+ 1.
+ 1.	
— 3.	— 3.
— 1. D.	— 2. D.

for if it takes a — 1. D. C. axis 90 to correct the error in the *horizontal* meridian then the *convergence* is for 40 inches, similar reasoning applying to the *vertical* where the focus is 20 inches.

QUESTION No. 16. By *static skiametry* with a + 1. D. S. lens before the patient's eye, if *reversal* occurs in the *vertical* meridian at 22 inches, and in the *horizontal* at 32 inches, what is the error?

ANSWER No. 16. — 0.25 D. S. $\subset$ — 0.50 D. C. axis 180.

REMARKS, No. 16. An analysis of this case shows *artificial myopia* to equal 1. D. If *reversal* occurs in the *vertical* meridian at 22 inches then the refraction must be 1.75 D. of *total myopia*. Deducting 1. D. of *artificial myopia* leaves a *true myopia* of 0.75 D. in this meridian.

In the *horizontal* meridian if *reversal* occurs at 32 inches the *total* refraction for this meridian is 1.25 D. Deducting the *artificial* as before leaves a *true myopia* of 0.25 D. C. 90, and by transposition the error is found to be neutralized by — 0.25 D. S. $\subset$ — 0.50 D. C. 180.

QUESTION No. 17. If 52. D. S. represents the total refraction of a standard eye, where will the points of reversal be

by *static skiametry* in an eye whose measurement in the *horizontal* meridian is 51. D. and 53. D. in the *vertical*, a + 2. D. S. lens being used?

ANSWER No. 17. *Horizontal* at 40 inches, *vertical* at 13 inches.

REMARKS, No. 17. Of course it is known that there is no such thing as a standard eye, any more than there is a standard ear or a standard tooth, etc., but for the purpose of trying to think in refractive parlance 52. D. has been suggested as representing the average *emmetropic* eye. This being the case, a meridian that shows only 51. D. is deficient 1. D. and is called *hyperopic*. The meridian showing 53. D. is over the required refraction and is therefore plus 1. D. or "*myopic*." Taking these into consideration the problem is expressed thus:

<i>Axis 90</i>	<i>Axis 180</i>
— 1.	+ 1.
+ 2.	+ 2.
+ 1.	+ 3.

QUESTION No. 18. In a patient having 3. D. *amplitude of accommodation*, how close to the eye (in inches) can a measurement be reliably made by *dynamic skiametry*?

ANSWER No. 18. Not nearer than 13 inches.

REMARKS, No. 18. Donders is authority for the statement that the near point of distinct vision in a child 10 years of age is two and three-quarter inches from the eyes. This distance reduced to diopters gives what is called *amplitude of accommodation* equal to 14. D. This *amplitude* diminishes as age advances, until at about 47 years of age the *amplitude* is only 3. D., hence it is wise for an examiner to keep these facts well in mind when using *dynamic skiametry*, then the *error* will not

become confused with *presbyopia* when the "p p" has been reduced to 13 inches.

QUESTION No. 19. In a patient ten years of age showing *convergent strabismus*, how close to the eye should *dynamic* measurements be made?

ANSWER No. 19. Ten inches is generally near enough, because it is inside of the usual reading point of the patient.

REMARKS, No 19. When *strabismus* is present, however, it indicates a marked disturbance between *accommodation* and *convergence*, and the examiner has every reason to suspect a pronounced error of refraction which, by the way, is *not always* found, but the examiner should proceed in a manner that will uncover all *errors* present, and if the patient is very young, say five years old, then a *dynamic* measurement up to within 6 or 7 inches will be wise.

QUESTION No. 20. By *dynamic skiametry*, when patients are from twenty to thirty-five years of age, how near should measurements for refractive errors usually be made?

ANSWER No. 20. About 15 inches away is near enough.

REMARKS, No. 20. In noting these different points for varying ages the student should exercise judgment. If the error is *hyperopic* then the nearer to the limit of *amplitude* an *examination* is made the more of the so-called *latent* will be uncovered.

If the error is *myopic* then nearness of examination is not always productive of the best results, especially in cases that have never worn correcting lenses.

QUESTION No. 21. By *dynamic skiametry* where patients are from thirty-five to fifty years of age, how near should measurements for refractive errors usually be made?

ANSWER No. 21. Measure at two points, 13 and 40 inches.

REMARKS, No. 21. The nearer to the so-called *presbyopic* age a patient approaches the more careful an examiner should be to not get inside of the *punctum proximum*, hence data from two points should be made.

Persons whose eyes are *emmetropic* usually do not require reading glasses until about their forty-seventh year of age. But so few eyes are really *emmetropic* that this age is the exception rather than the rule. *Presbyopia*, however, frequently serves to uncover slight *hyperopic* errors about the fortieth year of age, and this slight *hyperopia* is sometimes mistaken for *presbyopia*, the same as *presbyopia* can be mistaken for *hyperopia* if the "p p" is lost sight of.

QUESTION No. 22. When patients are over fifty years of age, how should their eyes be measured?

ANSWER No. 22. By both *static* and *dynamic skiametry*.

REMARKS, No. 22. It is quite surprising what an active *accommodation* some old persons retain, so whenever there is a history of eye-strain an examiner should always search deeply for *latent* errors.

The practice of making three *skiametric* measurements with fixation at 13, 40 and 240 inches, is an excellent means for arriving at the correct judgment necessary to succeed.

QUESTION No. 23. By *dynamic skiametry*, how near should measurements for *presbyopia* be made?

ANSWER No. 23. Thirteen to sixteen inches, or at the usual reading point.

REMARKS, No. 23. Reading and working distances vary so with different persons that no fixed rule can be laid down for an examiner's guidance. Questioning a patient as to his occu-

pation and visual requirements often uncovers valuable data. Then following the *subjective* test with a *skiametric* examination, where fixation and observation are at the patient's individual reading point, will enable the skillful examiner to quickly detect over and under-connections.

It will be noted, in passing, that *dynamic skiametry* thus offers the only *objective* means known for measuring *presbyopia*.

QUESTION No. 24. By *dynamic skiametry* with *fixation* at 40 inches and *observation* at 36 inches, if *emmetropia* is present what will be the action of the shadow?

ANSWER No. 24. It will move *with* the mirror.

REMARKS, No. 24. The quick speed of the shadow, and the vagueness of its definition, often show to the skillful examiner that he is close to the point of *reversal*. The difference in focal strength between 36 and 40 inches is only about 0.12 D., and it requires considerable skill to detect a difference of so small a quantity.

It will be remembered, however, that in pronounced errors the shadows are heavy and well defined, though sluggish in motion, whereas, in slight errors the shadows are faint, poorly defined and rapid in motion.

QUESTION No. 25. By *dynamic skiametry* with *fixation* and *observation* at 38 inches, if the shadow shows no movement, either *with* or *against* the plane mirror, what should an examiner do in order to determine the presence or absence of *hypermetropia*?

ANSWER No. 25. Add *plus spheric* lenses until *reversal* occurs. The strength of the added lenses *just before this takes place* will represent the error.

REMARKS, No. 25. This question involves one of the baffling points in *dynamic skiametry* to many who do not go into the subject deeply.

An eye with 2. D. of *hyperopia* in fixing at a point 40 inches away makes 3. D. of *accommodative* effort, and by *skiametry* may show no motion whatever. But if *plus* lenses are added the *accommodation* will relax to the point where *accommodative myopia* is a factor, when the shadow will then show an *against* motion.

QUESTION No. 26. By *dynamic skiametry* with *fixation* at 40 inches and *reversal* in all meridians at 26 inches, what is the kind and amount of the error?

ANSWER No. 26. 0.50 D. of *myopia*.

REMARKS, No. 26. This question involves two kinds of *myopia*, *accommodative* and *true*, and the difference between where the point of *reversal* ought to be and where it really is represents the error.

This eye having 0.50 D. of *true myopia* has a *punctum remotum* of 80 inches, and in looking at an object 40 inches away it would seem as though only 0.50 D. of *accommodative* effort would be used. But in fixing at 40 inches 3 degrees of *convergence* are called for and this, in turn, requires 1. D. of *accommodation*, so it can be readily seen why the point of *reversal* was less than that of *fixation*.

QUESTION No. 27. By *dynamic skiametry* with *fixation* and *observation* at 26 inches, if an eye accepts a plus 1.25 D. S. lens before *reversal* occurs, what is the error?

ANSWER No. 27. 1.25 D. of *hypermetropia*.

REMARKS, No. 27. The theories involved in this question cover, perhaps, the simplest principles called for in the *dynamic*

method. *Fixation* and *observation* being at a common point, all an examiner has to do is to find out how much *accommodative* relaxation he can obtain.

An *emmetropic* eye in looking at an object 26 inches away makes an *accommodative* effort equal to 1.50 D. In this case, however, the error and the fixation called for 2.75 D. of *accommodation*, and so when a lens of plus 1.25 D. S. was given the *accommodation* then relaxed this amount. And the reason it did not relax more than this was because *convergence* locked it, by interfering with a further surrender until *convergence* was altered.

QUESTION No. 28. Now, suppose the case in Question No. 27 had shown a *hyperopic* error of 0.75 D. by the *static* method, how would this difference be explained?

ANSWER No. 28. As a *spasm of accommodation*. The difference being what is called a *latent* error.

REMARKS, No. 28. Here is a question in which tension of *accommodation* is a factor. While the eyes are fixing at a distance it is found that 0.75 D. is all the relaxation that can be obtained, but when this same eye is exerted for a focal adjustment of 26 inches then the relaxation is more, and if the *fixation* was still nearer perhaps the relaxation would be slightly greater.

It is this known data for different distances that enables an examiner to formulate a better prescription than if the data was limited to, say, *subjective* tests alone.

In *dynamic skiametry* it is not contended that the relationship between *accommodation* and *convergence* is a fixed quantity. The "1 to 3" standard is merely used to aid in explanation. *Esophoria* and *exophoria* are factors, of course, the same as *myopia* and *hyperopia*. And it is the determination of the

special relationship in individual cases that makes *dynamic skiametry* of such great value for, after all, every case can be truthfully called "special."

QUESTION No. 29. By *dynamic skiametry* with *fixation* and *observation* at 40 inches, suppose a plus 1. D. S. lens can be added before reversal occurs, but at 16 inches a plus 1.50 D. S. lens can be used before *reversal* takes place, what condition does this indicate?

ANSWER No. 29. Either so-called *latent hyperopia*, or an abnormal relationship between *accommodation* and *convergence*, sometimes termed "*sub-normal presbyopia*."

REMARKS, No. 29. The old saying that "A rose by any other name smells just as sweet," is applicable in the above case, for it really matters little, in a practical sense, whether the need of stronger glasses in reading, than are required for distance, is due to early *presbyopia*, *esophoria* or *latent hyperopia*. What an examiner really desires to find out are the facts in the case, so he can govern his judgment accordingly.

QUESTION No. 30. By *dynamic skiametry* with *fixation* and *observation* at 37 inches, if it takes a plus 1. D. lens to cause *reversal* in the *vertical* meridian, and a plus 1.50 D. lens to cause *reversal* in the *horizontal*, what is the error?

ANSWER No. 30. 1. D. of *hyperopia* and 0.50 D. of *hyperopic astigmatism*, at axis 90.

REMARKS, No. 30. This is a case of measuring the two chief meridians of the eye. The least refractive error represents the *spheric* quantity, while the difference between the two represents the *cylindric*, the *axis*, of course, being in the direction of least error.

QUESTION No. 31. By *dynamic skiametry* with *fixation* at 40 inches, the patient wearing a plus 1. D. S. lens, if *reversal* is found at 22 inches, what is the kind and amount of the error?

ANSWER No. 31. 0.25 D. of *hyperopia*.

REMARKS, No. 31. This question involves two kinds of *myopia*, *accommodative* and *artificial*. The *accommodative* represents 1. D. and the artificial, 1. D., while the total is shown by the reversal point to be only 1.75 D., hence it follows that *hyperopia* must be present to absorb the difference between the sum of the *accommodative* and the *artificial myopia*, which equals 2. D., and that represented by the *reversal* point, of 1.75 D.

If the *reversal* point had been at 18 inches then the error would have been 0.25 D. of *true myopia*.

QUESTION No. 32. By *dynamic skiametry* with *fixation* at 40 inches and *reversal* in the *vertical* meridian at 22 inches, and in the *horizontal* at 32 inches, what is the formula of the lens that will neutralize this error? The formula may be written two ways.

ANSWER No. 32.

— 0.25 D. S. $\ominus$ — 0.50 D. C. 180, or

— 0.75 D. S. $\ominus$ + 0.50 D. C. 90.

REMARKS, No. 32. With *fixation* equal to 1. D. and *reversal* at 1.75 D. the error in the *vertical* meridian can be corrected with — 0.75 D. C. axis 180. And with *fixation* equal to 1. D. and *reversal* at 1.25 D. in the *horizontal* the error is correctable with a lens of — 0.25 D. C. axis 90. These crossed *cylinders* transposed equal the formulas given in the answer.

Ray-value corrections, or where the distance that *reversal* occurs is noted, can always be proven by *lens-value* ones, or where lenses are used to produce *reversal*, by simply using the

lenses called for by the formula and then noting whether the shadow behaves the same as it would in *emmetropia*.

QUESTION No. 33. By *dynamic skiametry*, with *fixation* and *observation* the same, where patient is wearing a lens measuring $+ 0.25$ D. S. $\ominus + 0.50$ D. C. axis 150 and it is found that an added lens power equal to $+ 0.25$ D. S. can be given in the 60th meridian before *reversal* occurs, but this same lens causes motion *against* in the 150th meridian, what is the correct formula?

ANSWER No. 33. $+ 0.25$ D. S. $\ominus + 0.75$ D. C. 150.

REMARKS, No. 33. The patient's lens, as above, reduced to its cylindric equivalent gives a total of

Axis 60

$+ 0.25$

Axis 150

$+ 0.75$

If an added $+ 0.25$ D. can be given in the 60th meridian, but not in the 150th, then 0.25 D. C. axis 150 is to be added to the patient's lens for a new formula and this transposed gives the answer.

Measurements made over a patient's own glasses offer a very convenient means for quickly determining whether they are correct or not.

QUESTION No. 34. By *dynamic skiametry* where patient is wearing a lens of $- 0.50$ D. S. $\ominus - 0.87$ D. C. axis 105 and it is found that a combination of $+ 0.12$ D. S. $\ominus - 0.25$ D. C. axis 15 is required to give a slight motion *with* in all meridians, *fixation* and *observation* being the same, and made at 16 and 40-inch distances, what are the correct formulas that may be given?

ANSWER No. 34.

$- 0.63$ D. C. $\ominus - 1.25$ D. C. 105.

$- 0.63$ D. S. $\ominus - 0.63$ D. C. 105.

$- 1.25$ D. S. $\ominus + 0.63$ D. C. 15.

REMARKS, No. 34. The *cylindric equivalent* of the patient's lens together with the added quantity shows:

<i>Axis 15</i>	<i>Axis 105</i>
— 0.50	— 0.50
+ 0.12	— 0.87
— 0.25	+ 0.12
— 0.63	— 1.25

Transposition then follows.

QUESTION No. 35. By *dynamic skiametry*, why should all measurements be made in a *binocular* manner, that is, by measuring first one eye then the other, then back to the first one again, and then to the second, and so on, with and without covering either eye?

ANSWER No. 35. To insure uniform muscular relaxation.

REMARKS, No. 35. This question involves co-ordinate fixation, for as one hand is usually more active than the other so is one eye usually more active than its mate, the most active one being called the "*fixing eye*," the other lagging along until compelled to exert itself.

It is said that in cases of *convergent strabismus*, due to *hyperopia*, if the *fixing eye* has its refractive error fully neutralized with lenses the straightening will occur even where no correction is given for the deviating eye. Thus showing the supremacy of the eye of *fixation*.

At the beginning of a *skiametric* examination the operator can not tell which eye has the best vision, as this is left for the *subjective* test to determine, and so it sometimes happens that the eye with the greatest error is the one of *fixation*. It will be seen, then, how important it is for the skiametrists to make his examination in the manner here referred to.

QUESTION No. 36. With an *esophoria* of 6 degrees, what kind and amount of refractive error should a patient have in order to theoretically harmonize his *accommodation*.

ANSWER No. 36. About 2. D. of *myopia*.

REMARKS, No. 36. From the foregoing it will be seen how unwise it is to adapt prisms when the *myopia* present has never been corrected.

A wise procedure in all *heterophoric* cases, undergoing their first examination, is to give correction for the refractive errors found, and then to await nature's effort to adapt herself to the new order of relationship between *accommodation* and *convergence*.

Prisms may have to be given in the end, but they should never be adapted at a first sitting if it can possibly be avoided.

QUESTION No. 37. With 2. D. of *hyperopia* what kind and amount of *heterophoria* should be present in order to theoretically harmonize the patient's *convergence*?

ANSWER No. 37. About 6 degrees of *exophoria*.

REMARKS, No. 37. This is the opposite of Question No. 36. If 2. D. of *accommodation* calls for 6 degrees of *convergence*, then an eye that makes 2. D. of *accommodation* for *infinity* must suppress this 6 degrees, or else be *exophoric* this amount, hence it follows that suppressed *convergence* shows theoretic *divergence*.

Extrinsic muscles that are mal-attached, or are affected by paralysis, do not, of course, come under the same treatment as those involving errors of refraction and the consequent disturbance in their correlation with the *intrinsic* muscles.

It is plain, to be sure, that an examiner at a first sitting does not know the true cause of whatever *heterophoria* he may find,

but if a marked uncorrected error of refraction is present it behooves him to neutralize as much of this error as he can before resorting to *prisms*.

QUESTION No. 38. Why is *convergent strabismus* sometimes a concomitant of high degrees of *hyperopia*?

ANSWER No. 38. Because in the excessive muscular effort put forward by the *accommodation*, in order to neutralize the error, the *convergence* is overexerted, too, and then the patient unconsciously learns to see better with the *fixing eye* by suppressing vision in the *deviating* one, thus permitting it to turn inward as far as it likes.

REMARKS, No. 38. In *convergent strabismus* cases, while vision is often suppressed, the extrinsic muscle action is not, and this therefore accounts for the marked deviation from the standards controlling normal co-ordination.

QUESTION No. 39. Why is *divergent strabismus* sometimes a concomitant of high degrees of *myopia*?

ANSWER No. 39. Because, owing to the non-use of *accommodation*, intrinsic muscular effort is not required to produce focal adjustment. *Convergence* thus failing to receive associate stimulation lags behind and, frequently, one eye learns to suppress vision, thereby losing its power of co-ordination.

REMARKS, No. 39. *Short* explanations of what might be called *long* subjects may be pleasing to students, but they are often misleading on account of their very shortness. For this reason all searches after *optometric* facts are counseled to delve deeply into the underlying causes responsible for disturbed relationships between *accommodation* and *convergence*, in all sorts and conditions of cases.

The subjects of *heterophoria* and *heterotropia* have been touched upon here simply because of their being aggravated phases of many lesser disturbances due to the common source of inco-ordinate *accommodation* and *convergence*.

QUESTION No. 40. What is the relative value of *objective* optometric methods as compared to *subjective* ones?

ANSWER No. 40. As *one* is to *one*.

REMARKS, No. 40. Every *optometric* method of merit becomes useful to the optometrist in some case at some time. It therefore behooves all ambitious examiners to thoroughly acquaint themselves with the principles underlying every *optometric* method, as this places them in a position to be able to judge for themselves, for, while the taking of ocular measurements is often comparatively easy, it is the formation of correct judgment that in the end can be said to *make* an examiner's reputation, while if incorrect it may *break* it.

CHAPTER XII.

OPINIONS OF OTHERS REGARDING THE VALUE OF SKIAMETRY
IN GENERAL AND THE DYNAMIC METHOD IN PARTICULAR,
WITH COMMENTS ON OBJECTIVE VERSUS SUBJECTIVE
OPTOMETRY, AND THE RELATIONSHIP OF ACCOMMODATION
AND CONVERGENCE.—INCLUDING QUOTATIONS ON MEN-
TAL PERCEPTION, AND AN EPILOGUE.

No matter how meritorious a method may be there are always some well-meaning persons who prefer to hear the opinions of others first, and if these expressions are favorable they feel warranted in taking up the subject themselves with a view to its mastery. Then, too, there are the "Doubting Thomases" who sometimes get started on the wrong line of reasoning and become sadly tangled, due, perhaps, to some early misconceptions. It may be truthfully stated, however, that all reasoners unquestionably try hard to do a subject justice, and for this reason their arguments, like the logic of an opposing attorney, is well worth listening to, therefore, before closing this little volume, it is thought best to hear all sides regarding *dynamic skiametry* by quoting from sources independent of the author, and in this way the *pros* and *cons* may serve a useful purpose. The following selections have therefore been made:

OPINIONS OF OTHERS. A. W. STAMMER, in the *London Optician*, for April, 1910, writes:

"I want to describe one or two simple experiments that any optician with a test case can try, and which will give him a better idea of the way in which the extrinsic muscles work than will weeks

of book study. In all that follows it must be remembered that the optical instrument theory is completely ignored, and later it will be seen why.

"The first text book statement that does nothing but confuse students is that there is a definite co-relation between the functions of accommodation and convergence. This is absolutely true as far as it goes, and while you regard the eye as an instrument conforming to mathematical laws requires no modification. It was once believed that there was a co-relation so perfect that someone brought out a system of testing called *dynamic skiascopy* that was based on this fact. That system failed for the reason that there is no fixed relation between these two functions. Try the following experiments yourself, and I think you will see what I mean.

"Look at the distance test charts through a pair of minus two spheres and you will see each letter quite single. You are accommodating to the amount of two dioptrics, but you are not converging, or you would see everything double. If it were not possible to use these two functions independently, no living person who was hypermetropic could see anything single. Again; look at the chart through a pair of six degree prisms base out, and you will still see things single and quite clear. If you were accommodating you would be for the time being myopic and it would be necessary for you to use minus lenses to see the chart clearly. You will see for yourself that it is not so; I can myself read 6/6 with a ten degree prism base out in each eye. This is found in daily practice in the case of a presbyope who reads at thirteen inches with a + 3.0 addition for reading. In all presbyopes of a certain age there is convergence for the reading distance with absolutely no accommodation.

"Now, your first experiment proved that you can accommodate and not converge, and the second that you can converge and not accommodate. What *does* control the co-relation of these two functions? Simply this, the desire first for single vision, and then for clear vision; and these results are obtained by co-relation between the *brain* and the *retina*."

The *Optical Journal* for May 26, 1910, contained the following from F. A. WAMBOLD:

"It is certainly true that testing by *dynamic skiascopy* is a failure. It always will be; but the reason is not found in the fact that there is no fixed relation between convergence and accommodation; no

such fact exists. The opposite is true, as nature made those two functions work automatically.

"It seems so reasonable, so natural, to think they work in partnership. They are controlled by the same wires, the third nerve through which the nervous energy is applied. It is the nervous supply way back in the brain that gives power to those intrinsic and extrinsic muscles, and to the recti interni and externi. The same supply that runs the whole machinery also gives power to the muscles that operate the crystalline lens and the eyeball, to cause the lens to bulge out, and to turn the eye out again when turned in.

"In solving that question of association of convergence and accommodation, we must not forget the function of the recti externi muscles which get their supply by way of the sixth nerve.

"Try the same experiments suggested by Mr. A. W. Stammer. Put those same minus 2 spheres in front of your eyes and look at the test chart. If you have the power to overcome the glass, and in addition any defect you may happen to have, you will of course not see double. Vision will be single. Why? Not because there has been no convergence in response to the accommodation that was necessary to bring the foci on the retina. No, not that; they had converged; they should have and they did. The wattage that went over the wires of the third nerve to the ciliary went also over the same wires to the recti interni muscles, and pulled the eyes in at the same ratio the force was applied to the ciliary.

"But that created a condition that should not be, and in goes the message to the brain center to turn on the power on the sixth line that controls the externi, and the eyes are pulled straight again. That's why you do not see double, why you have single vision looking through that minus 2 lens. If this were not the case, that is, if those muscles had not that function, that duty, then it would have been conclusive and logical to say, 'no living person who was hypermetropic could see anything single.'

"For the same reason you see things single looking through a six degree prism. The prism, base *out*, turns the eyes in and forces the accommodation, and vision would be blurred if it weren't for the fact that nervous energy applied by way of the sixth nerve through the externi pulled them straight again. It will do it every time, provided the supply is equal to the demand.

"So you see plainly that said conclusions are based on false grounds and test must fall.

"Look at this statement: 'If they converge, they will see double and the retina will at once inform the brain of the fact, and the recti interni will receive instructions to relax until the image on each eye is on the fovea.'

"I will concede the first, but deny the return message, 'the instruction given by the brain to relax.' The brain knows better. It knows what those externi muscles are there for, and turns on the nerve wattages on the sixth nerve to stimulate those outer muscles to turn the eyes straight—and straight they come. That is the function of those muscles. We must then not forget and disregard the function of the recti externi. Of course, that means an extra supply to be turned on in that direction. If the supply be insufficient the eyes will remain converging and the person will see double. Contraction is not the cause that turns the eyes in, it is an exhibit of the nervous energy applied. The nervous energy going over the same wires that control the accommodating and converging muscles are the causative factors. The nerve-wattage turned on the sixth nerve neutralizes the first exhibit and eyes come straight. See! It is true that said interni muscles relax, but not in response to any direct instruction from the brain to do so. It does it because of the negative pull against it which exactly neutralizes its contracting effort; the muscles are not to blame.

"The automatic relationship of convergence and accommodation stands. Why *dynamic skiascopy* is a failure; that is another story. The failure to understand this phenomenon has another reason. It is a lack of a correct and complete understanding of the physical laws of optics."

MR. H. B. MOORE, in a paper read before the *Colorado State Optical Society*, July, 1910, stated as follows:

"The static method is to place a $+ 1.00$ D. lens in the trial frame in front of each eye; then rotate the mirror at a distance of 40 inches from the eye, requesting the patient to look at the test card 20 feet away, and if the shadow remains still in the meridians, then the case is emmetropic, as the $+ 1.00$ D. lens just neutralizes the distance between the optometrist and the patient. If the shadow moves with the mirror, the case is hyperopic, and if it moves against, it is myopic, and from all retinoscopic findings in this method, a $+ 1.00$ D. should be deducted.

"The dynamic method is just the reverse of the static, and a system of shadow testing where the accommodation is active. In this method the patient is directed to read a small card of different size letters, placed on the forehead of the optometrist 40 inches away; now to do this he has to use 1.00 D. of his accommodation. Now, let the deep-thinking optometrist follow this explanation closely, then he can judge as to the real value of this method, *as it is the writer's intention to give facts and prove that this method, which seems so nice in theory, does not meet with accurate results when in practical use.*

"Here are a few examples as follows—first case: if the eye is emmetropic the rays of light will emerge parallel and the 1.00 D. of accommodation will converge these rays and cause them to focus at a distance of 40 inches and no motion will be observed in either meridian, as the 1.00 D. of accommodation used takes the place of the + 1.00 D. lens that is used in the static method.

"Second case: if the patient has 1.00 D. of hyperopia he will be obliged to use 1.00 D. of his accommodation to see the test card clearly at a distance of 20 feet and 1.00 D. to read the brow card at a distance of 40 inches, thus making a total of 2.00 D. of accommodation used.

"Third case: suppose a patient has 1.00 D. of myopia; his far point for distance vision is 40 inches and the emergent rays will focus at this point, and the patient will not use any accommodation to read the brow card.

"Now, it is claimed by the exponents of the dynamic method that it is impossible to separate accommodation and convergence by placing the plus lenses in front of the eyes, except for hyperopia they may have. In the first case we find the eye emmetropic using 1.00 D. of accommodation. They place plus lenses in front of the eye and find the strongest that will be accepted without reversing the shadow. In an emmetropic eye, they state that a + 0.25 D. will cause a reversal even though the eye is accommodating 1.00 D.

"In the second case we find the eye using 2.00 D. of accommodation. They claim that this eye will relax 1.00 D., for it is that much hyperopic, but it cannot relax any of the other 1.00 D. as the convergence checks it so it will not relax.

"In the third case, the eye being myopic 1.00 D., no accommodation is in use. They place an over-correction of minus spheres, rendering

the refraction of this case hyperopic. Then they gradually reduce with minus spheres until they find a point of reversal.

"The special advantage claimed by the exponents of this system is: in case of a spasm of accommodation sometimes found in a case of hyperopia. The eyes will test myopic at 40 inches because the spasm holds the focus in front of the retina. The spasm covers the 1.00 D. of hyperopia and renders the eye myopic 1.00 D. and at 40 inches the motion is seen to move against the mirror. Now, advance the mirror to 10 inches, requesting the patient to read the brow card; this calls for 4.00 D. of accommodation, and as the patient has a spasm of 2.00 D. covering his 1.00 D. of hyperopia, thus bringing the focus 1.00 D. in front of the retina, so it will only be necessary for him to use 3.00 D. of his accommodation. This absorbs the spasm and gives a chance to measure as much as 3.00 D. of hyperopia; but right here the dynamic exponents claim that he will accept just 1.00 D., as this is the amount of his hyperopia and that his convergence checks the relaxation at this point; but does it?

"This whole system hinges upon their theory that accommodation and convergence are so closely related that by placing plus lenses in front of the eyes this relation cannot be disturbed. If we allow the exponents their premise in an argument, we generally have to admit it, as their reasoning will be logical all the way through. If right here we take pains to experiment so we can determine the truthfulness of their first proposition then we will discover why this method proves up inaccurate in nearly 90 per cent. of all its cases. The writer states fearlessly that convergence is not a check upon accommodation and will prove it by the following experiments:

"Now, listen: if the exponents are right in the relation of these two functions in their shadow test, it surely ought to be demonstrated with lenses subjectively. Take persons with emmetropic eyes and if we place — 2.50 D. spheres in front of their eyes, and in order that they can read the 20/20 line, on the test card 20 feet away, they will have to use 2.00 D. of their accommodation. The 20/20 line on the test card 20 feet away is perfectly plain, bearing in mind that their accommodation is fixed for 16 inches. This ought to prove most conclusively to any optometrist that under the above-named conditions the accommodation can be exercised 2.50 D. while the convergence remains fixed for 20 feet. If we were to increase the strength

of the minus spheres, it would produce diplopia, thus showing that 2.50 D. is the limit of their power of separation between these two functions.

"In another experiment we find that they can read the 20/20 line perfectly with 25 degree prisms (half of the amount over each eye) base out. This shows that they can send a nerve force to the internal muscles without affecting the ciliary muscles in the least. It seems to the writer as if these two last experiments, which can be made on yourself or anyone else, ought to convince any deep-thinking optometrist of the inaccuracy of the theory of the dynamic method.

"In all cases of hyperopia, except the 'squints,' we find these two functions working entirely out of harmony with each other, showing the wonderful power of adjustment in nature. In all cases of myopia we have the same conditions reversed, for while the convergence is fixed for 20 feet, the accommodation is nearer to the eye according to the myopia."

In giving his opinion as to what constituted the best *skiametric* method, Mr. Moore further stated:

"The fogging method of retinoscopy is one that relaxes all accommodation, as it is an active accommodation that is responsible for many errors in refraction. The test is made by placing a plus 4.00 D. lens before the eyes and having the patient look off into space. This renders the eyes myopic and puts them in a condition of rest. If the eyes are emmetropic, the emergent rays will be parallel and a + 4.00 D. sphere will bring these parallel rays to a focus at 10 inches in front of the lens. As you observe the motion of the shadow from 40 inches, you will find the eye decidedly myopic. Move closer and closer until you reach the point of no motion. Measure from the lens to the mirror, and if the eyes are emmetropic you will find the neutral point or conjugate foci to be 10 inches. If your case happens to be hyperopic of 1.00 D. the rays of light will emerge 1.00 D. divergent; as it requires 1.00 D. of your + 4.00 D. to make these rays parallel, they will be brought to a focus 13 inches from the eye. The motion will reverse at this point. In all cases of myopia the emergent rays are convergent and the + 4.00 D. will make them still more convergent. If there is 1.00 D. of myopia, the convergent rays would focus at 40 inches without any lens. Placing a 4.00 D. sphere in front of the eye causes the rays to focus at 8 inches in front of the lens.

"If we wish to be exact in our measurements in this or other methods we can attach a tape measure to our trial frame and hold the same in one hand, while we rotate the mirror with the other, at the required distance. In the fogging method this will give you the exact distance between the lens and the mirror and you will find your conjugate foci. The rule to follow is: place a $+ 4.00$ D. sphere in front of both eyes. Reflect the light with a plane mirror into the eye and find the point where there is no motion. If it is at the focal point of the lens 10 inches, the eye is emmetropic."

MR. R. M. LOCKWOOD, of New York, the scientific editor of the *Optical Journal*, in a lecture on "*Dynamic Optometry*," before the *Optometric Society of the City of New York*, March 9, 1910, among other things, said:

"The first variety of dynamic optometry, to which attention has been called in recent years, is the dynamic test with the skiascope, called by the deviser of the system, A. Jay Cross, of New York, 'dynamic skiametry,' and elucidated and discussed in his work, '*A System of Ocular Skiametry*.'"

"The practice of dynamic skiametry is based on the theoretically strong inter-relation of accommodation and convergence, so that if a fixation chart be placed at some point which is near to the eyes under test the accommodation for that distance and the convergence necessary for the same distance will act together with the result that, when the neutralizing lens has been found for that distance, the lenses in the frame will be the correction for distance, without any allowance being made for the point at which the test is made. As will be seen, the fundamental difference between the static method and dynamic skiametry is that with the static test the fixation chart, if any is used, is twenty feet away, while with the dynamic method the fixation chart is brought to approximately the plane of the observer's eye. In this latter case it is claimed that there is a certain amount of the accommodation exerted which will not relax, and this is due to the fact that the accommodation and the convergence are acting together, and that the relation between these two functions is a very strong one.

"Suppose we find, with the fixation chart attached to the skiascope, that it requires a plus 1.50 sphere to make the shadow neutral; then, according to the theory of dynamic skiametry, plus 1.50 is the correction for distance, unless the accommodation is deficient, no matter

at what point the test is made. Suppose the test is made at twenty inches from the patient's eye, then, the fact that he is accommodating for twenty inches and converging for twenty inches means that the ciliary exerts two diopters of accommodation which it will not relax so long as the fixation chart over the skiascope is fixed, but as this two diopters will relax when the attention passes from this chart to the distance, then the correction in the frame is the correction for distance, the accommodation supplying the amount of power necessary to have the attention come up from distance to the plane of the chart. The author of dynamic skiametry claims that part of this accommodation, exerted because of the near location of the chart and the interaction of accommodation and convergence, will be the ciliary spasm present, if any; so that in this supposed case the two diopters of accommodation exerted because of the location of the fixation chart will be made up of the amount of the spasm and in addition the necessary extra effort required to make up the full amount; hence the method, he claims, is an infallible detector of ciliary spasm, and if the full correction as shown in the trial frame cannot be worn at first it may in time, when the spasm wears off, if it ever does. Incidentally it is found according to this theory that spasm of the accommodation is a widespread condition in eyes.

"Now, I have explained the fundamental point of dynamic skiametry as the author gives it, though I do not accept it that way. I appreciate the great value of the method, and it was the consideration of this method over a space of many months that led me to the formulating of another theory, which not only takes in dynamic tests with the skiascope, but similar tests with the trial-case lenses, both of which I have grouped under the term 'dynamic optometry,' meaning the act of testing eyes with the accommodation purposely in force for the purpose of finding that correction which will be harmonious for any selected distance without either the innervations involved being too great or too little; or, in other words, the finding that correction which will give comfortable vision."

T. G. ATKINSON, M.D., of Chicago, editor of the *Medical Standard*, and of the *Optometric Department* of the *National Jeweler and Optician*, in the issue of the latter publication for August, 1909, says, in part:

"Speaking seriously, we do not believe that the importance and significance of dynamic skiametry is anything like properly appreciated,

even by those who are capable of grasping its import. It is, in our judgment, by far the most momentous step in optometry since the days of Donders. Indeed, as we have previously remarked, it constitutes the line of demarcation between the old and new optometry, just as definitely as the spectroscope divides the old and new astronomy, and in much the same way, for the essence of dynamic skiametry, like that of spectroscopy, is that it furnishes a working method of measuring objective phenomena in active process. It is not alone the useful and valuable things which it enables the optometrist to do that gives far-reaching importance to the Cross system, but the revolutionary standpoint that it establishes, from which to approach and handle problems yet to arise.

"Specifically, the most notable practical advantages afforded by the dynamic system of skiametry are, first, that it furnishes an exact method of measuring refraction as it actually is, without any allowances for the ciliary muscle, and second, that it utilizes the well known principle of kinetic synergism, by which an active muscle will readily accept needed relief. A further advantage of the system, secondary from an optical point of view, but of prime importance from the optometrist's standpoint, is that it is the only method by which objective refraction can be reliably carried out without a cycloplegic, so that it is really a crucial, let us say the crucial, pivot around which revolves the entire sphere of optometry as an independent planet.

"Eventually, every optometrist will have to understand and practice dynamic skiametry. Eventually, so will every medical man who hopes to maintain his standing as a refractionist. The medical profession is foolishly engaged in the ostrich tactics of burying its head and shutting the new order of things out of vision, and will some day withdraw its silly head to find that it is outflanked and outdistanced. But there is nothing to exempt from the same fate the equally foolish optometrist who, while he recognizes the importance of the dynamic system and pays lip tribute to its author, neglects to avail himself of its principles and practice."

DR. H. J. COOK, ex-president of the *American Optical Association*, in a paper read before the *Tennessee State Optical Society*, July, 1910, gave his opinion of *dynamic skiametry* in the following words:

"In cracking some nuts along this line I will take some of the conundrums that have been given from time to time in the optical

publications and try to explain them by the aid of a set of rules which I gave before this body last year at Nashville, in more detailed form. It must be understood that 'rules' do not govern the shadow tests any more than they govern trial-case refraction, but they will be found a great help to the beginner in skiametry, as they fix the principles in the mind in the same way that the jingle of old times fixed the odd days of the months, 'Thirty days hath September, April, June and November.' This great discovery of A. Jay Cross is the only method by which the total refraction of an eye can be estimated without the use of drugs. It is the only *objective* method that can be used in presbyopia. It can uncover spasm when all other systems fail. Its value is so great that it seems a waste of time to say that every refractionist should use it—at least in corroboration of other methods.

"I take it that you are familiar with shadow appearance, shadow motion, mirrors, lights, dark room accessories, and, above all, with the laws relating to conjugate foci. We are taught that rays from an object emerge from the eye along the same path by which they entered it; thus the parallel rays emerging from the emmetropic eye and the divergent rays from the hyperopic eye must be made *convergent* in order to be intercepted at the crossing point by the mirror of the observer. As shadow reversal is at the focus conjugate with the retina, we must set up some form of myopia where real myopia does not exist. We have two ways of doing this: by fixation (or '*accommodative* myopia') or by plus lenses (*artificial* 'myopia'). We can deal with all three of the myopias, singly or combined.

"Though the real myope uses his accommodation less than the emmetrope, and the emmetrope less than the hyperope—the addition of artificial myopia to any of these by lenses, or by accommodation, increases proportionately the dioptric value of the media traversed by the rays from our mirror, and decreases proportionately the distance at which shadow reversal is located; hence we are to base our diagnosis of refractive errors upon differences between the *actual* location of reversal and the point where normally it *should* be found in conjunction with the myopia we have added. Hence the following rules:

"1. Fixation distance (accommodation) or plus lenses, or both, must be used to set up the incident focal point.

"2. Lenses and accommodation are added together in their values to create a myopic far point (point of reversal).

"3. Fixation and reversal points at same distance indicate emmetropia, or if brought together with plus lenses, corrected ametropia.

"4. Reversal found *beyond* fixation indicates hyperopia.

"5. Reversal found *inside* fixation indicates myopia.

"6. In presbyopia neutral point falls behind fixation, as hyperopia.

"The following 'nuts' were given in the *Optical Journal*, page 839, by A. W. Stammer in an argument to discredit the dynamic system on the ground that accommodation and convergence are variable and can be used independently. For this reason he condemns the system as worthless, and cites the following cases to prove his claim:

"Case 1. Emmetrope wearing minus 2. D. reads 20/20ths *without* convergence, but is using 2. D. accommodation alone.

"Case 2. Same emmetrope wears 6-degree prisms before each eye base out; can see normally at distance type without accommodation while strongly converging.

"Inasmuch as dioptric values and not convergence govern in shadow behavior, his condemnation of the system is based upon error. In neither case has one of the 'myopias' been set up, as required by rule 1.

"In case 1, the two diopters of accommodative effort was exactly balanced by the 2. D. of artificial hyperopia caused by the minus lens, thus nothing was added to the dioptric value.

"Case 2 comes under the same conditions. Rule 1 proves it. Convergence added no dioptric value to the eye in these exceptional cases, and in case 2, it is to see that the converging lines only extended to the outer surface of the prisms, becoming parallel thereafter.

"Quizzes have gone the rounds of optical publications tending to mystify those who do not dig deeply.

"Case 3. One of these asks, 'How can you get reversal of shadow at a fixation point, say 40 inches, from an hyperope of 1. D., while wearing his correction which makes him an emmetrope?'

"According to rule 1, accommodative myopia of 1. D. has been added to this eye by fixation, and another 1. D. by the plus lens, — 2. D. in all. If the case was an emmetrope this 2. D. addition would bring the reversal point up to 20 inches, the same as in real myopia *without* artificial aid. But his hyperopic divergency consumes 1. D. of the added power to bring the divergent lines to parallelism, while the remaining 1. D. can only bring reversal up to the fixation point of 40 inches. This accords with rules 1, 2, 3 and 4.

"Case 4. Cases which seem to disprove rules should be carefully examined. One in which distant vision blurs with the weakest plus lens, but is improved with a weak minus lens is a hard nut for trial case. Suppose mirror shows reversal at 32 inches while fixation is at 40 inches, for example. By rule 5 we suspect myopia, because reversal is found *inside* fixation. We move fixation card up to this reversal point, when, if true myopia exists, reversal is found at a corresponding distance forward (nearer patient), which will be in accordance with the dioptric value added, or 26 inches. If, instead of this forward movement, we find that reversal has lagged behind, we may expect spasm. Moving fixation card still nearer, say to the 26-inch reversal point, if the case *is* spasm, of the amount shown by the previous trial lens used, reversal will now be found *behind* the normally expected position, and will prove hyperopia, as per rules 1 and 4.

"In cases like this, the spasm has been completely swallowed up in the effort forced by close fixation, which was used in excess of the false myopia caused by the spasmodic effort. These cases are not rare, and should teach us to not stop at reversal, but use several *close* fixation points to corroborate, remembering that the principle is the same as in trial-case work, where we use the strongest plus at infinity, with which we get normal vision.

"I would not urge the use of this system in presbyopia, owing to the small pupils usually found, but this is a form of hyperopia, and premature presbyopia may often be found in people young enough to be carelessly credited with the average accommodation given in Donders' table, and it is not rare therefore, in using the system, to find cases of young people who need stronger glasses for reading than for distance.

"The near point can be located, as well as the desired reading distance in presbyopia, by dynamic skiametry."

In a paper on "Retinoscopy," by A. R. SLADER, read before the *Vermont State Optical Society*, in July, 1910, he says:

"As I have mentioned previously, and as all optometrists know, there are two distinct methods of making the test, called the static and dynamic. The static supposes the eye of the subject at rest—the accommodation being inactive—the focus being at infinity. By the dynamic method the accommodation is in force, the fixation being inside of infinity at a certain definite point. By the static method the eye tested is made artificially myopic by means of a plus lens repre-

senting the distance the test is made inside of infinity; $+0.50$ for 80 ins. or 2 meters, $+1.00$ for 40 ins., or one meter, $+1.50$ for 26 ins., $+2.00$ for 20 ins., etc. By the dynamic method the lens of the eye takes the place of the artificial lens, the eye being held to its position by means of a brow card or lettering on a standard that can be placed at any desired distance either back of the observer or in front of him. In using the static method myself I usually work at 40 ins. and place a $+1.00$ D. lens before the eye examined at once, then no deductions or changes are needed to be made at the close of the test, but simply the removal of the lens.

"The two methods differ only as regards the treatment of the accommodation of the subject. By the one it is suppressed; by the other it is put into action. When it is suppressed it is always a question whether it is fully suppressed or whether it is not exerted to a more or less degree. Especially is this true regarding this function in young people or where there may exist what is called spasm of the accommodation. In subjective tests we have the same problem, as we all know, to confront. The oculist disposes of it with the use of the cycloplegic, which paralyzes the function of accommodation, but it is a question whether this solution is wholly a happy one in view of the changes which need to be made in the resultant lenses to make them wearable, and the dangerous nature of the drugs employed.

"In static retinoscopy the darkened room helps to control the accommodation. Then some use the fogging method, placing strong lenses before the subject's eyes at first. It rests with dynamic skiascopy, to my mind, however, to supply the best means of overcoming the difficulty. This method originated with A. Jay Cross, and is amply explained by him in his book entitled 'A System of Ocular Skiametry,' which should be in the hands of every optometrist.

"By the *dynamic method* the accommodation of the subject is induced to work, and the theory is that the greater the burden placed upon these muscles the more inclined they are to give up any excess of energy which they might otherwise have exerted—that it really unlocks spasm of the accommodation—whether this is strictly so, or, as some assert, it only reveals that condition—whether between the co-ordinate functions of accommodation and convergence there is a fixed and immutable relationship—a diopter of accommodation calling for a meter angle of convergence, as the dynamic system theoretically implies—or, as others claim, it only shows whether the two functions are in harmony at a given point, certain it is that those who use this method regularly

find it of very great value and get very satisfactory results. I, myself, and I presume many others, use both methods, though the dynamic is the one most relied upon in hyperopic conditions with younger people.

"By the dynamic the test can be made at varying distances and with fixation of the subject's eyes at different points. Thus, while the retinoscope is used at 40 ins. or 1 meter, the eyes of the subject can be fixed at 80 ins. or at any other point inside of infinite distance and the operation of the shadow noted. The size of the reflex, rapidity of the shadow action, etc., will vary according to where and under what conditions it is viewed, and with some eyes one position is best and with some another. Again, in presbyopia it can be used to determine approximately the strength of lenses needed for the near work, the examination being made within the reading distance.

"But all the work with the retinoscope needs to be verified with the subjective test. It does not dispense with that form of test, but, in my opinion, the two should go hand in hand.

"In closing, I would say that I believe that every optometrist who attains the highest success in the profession must have a working knowledge of retinoscopy and use it constantly. Look at its advantages, my brother optometrists! *First of all*, it is an *objective method*. Such a method appeals to the public who furnish the eyes to be tested. The subjective trial-case method of examination, even if scientific and furnishing accurate results to the skilful operator, looks to the customer only like a roundabout method of having him select his own lenses. To be able to tell a person what he needs for glasses, without asking him or her any questions, by the simple flashing of a light into the person's eyes, certainly gives the man able to do it a professional standing in the opinion of the client that no subjective test will.

"Secondly—How simple and inexpensive the absolutely essential apparatus for the test is. All that is really needed is the little ordinary hand retinoscope—a bright light and a darkened room with the trial frame and lenses, that is all. Of course, adjustable chairs and other auxiliaries are desirable, but good results can be obtained under the most adverse conditions by one who is very familiar with the test and has become an expert.

"Thirdly—The accuracy of the results—Of course much of this depends upon the skill of the operator—"the man behind the gun," but so it is with any instrument or system of refraction—but given the

skilled operator, which practice will develop, and right conditions, and I believe there is no method of measuring refractive errors so exact.

"I have heard optometrists scoff at the idea of measuring astigmatism with the retinoscope to the small amount of a quarter of a diopter, but such scoffing only proves that the party is not a user of the retinoscope, or certainly has not acquired skill in diagnosing errors with it. To me it is of great value in differentiating $\frac{1}{4}$ diopter, or even less, of astigmatism, when unable to do it for a certainty with the trial case.

"Fourthly—It measures the dioptric system as a whole—not the cornea only, like the ophthalmometer.

"I believe in the subjective trial-case test. I presume it will always remain an important test and probably the 'court of last resort,' but the little retinoscope is a mighty power in the hands of the refractionist in difficult cases. With it and a practical knowledge of dynamic skiametry he has an equipment that will prove of immense value. Without it he is distinctly at a disadvantage when he meets adverse conditions."

Clias. A. JARVIS, in *Kansas City Jeweler*, says:

"The real value of *dynamic retinoscopy* lies in its ability to uncover latent hyperopia. It is invariably successful in cases where a physician would use a cycloplegic. For instance, if rotation of the mirror shows no perceptible movement at first, and when a plus lens is placed before the eye under examination and the movement is not against the mirror then we may take it that the accommodation has relaxed to accept the plus lens. The power of that lens which can be retained before the eye without causing the shadow to move against the mirror is the amount of latent hyperopia."

Under the caption of "*How Mydriatics act in Skiascopy*," MR. L. G. AMSDEN, the well-known editor of the *Canadian Optician*, in the issue for April, 1910, says:

"I am frequently in receipt of inquiries regarding the value of retinoscopy without the aid of a mydriatic, such queries being undoubtedly prompted by the fool statements made in text-books, usually written by medical men, in which the stereotyped phrase is always found: 'The test is, of course, impossible and unreliable without the use of the mydriatic.'"

"Now, the truth is—and it is becoming generally recognized—that accurate results are impossible in retinoscopy when a mydriatic is used, owing to the fact that the enlarged pupil brings under examination certain parts of both cornea and lens that are not used under ordinary conditions, and which may possess curvature of an entirely different nature to that used in regular vision."

A. S. HASKINS, Treasurer A. O. A., in the *Optical Journal* of May 5, 1910, says:

"Much is being written regarding subjective and objective optometry. Generally, little favor is given the latter. The same ones who speak against objective optometry are among those who believe that 20 years will show great advancement in optometry. Certainly, if optometry advances it must be along objective lines. Much of this predicted advancement will be the mastery of the present objective methods by the ones who, to-day, think so little of them."

MENTAL PERCEPTION. As having a bearing upon the question of the relative value of *subjective* and *objective* optometry, a short consideration of the subject of *mental perception*, in general, may emphasize certain points showing why it is unwise for optometrists to rely implicitly upon subjective data alone, extracts will therefore again be made from the pages of *James' Briefer Psychology*, in which he says:

"Anything which affects our sense-organs does also more than that: it arouses processes in the hemispheres which are partly due to the organization of that organ by past experiences, and the results of which in consciousness are described as ideas which the sensation suggests. The first of these ideas is that of the thing to which the sensible quality belongs. *The consciousness of particular material things present to sense* is nowadays called *perception*. The consciousness of such things may be more or less complete; it may be of the mere name of the thing and its other essential attributes, or it may be of the thing's various remoter relations. It is impossible to draw any

sharp line of distinction between the barer and the richer consciousness, because the moment we get beyond the first crude sensation all our consciousness is of what is *suggested*, and the various suggestions shade gradually into each other, being one and all products of the same psychological machinery of association. In the directer consciousness fewer, in the remoter more, associative processes are brought into play.

“Every concrete particular material thing is a conflux of sensible qualities, with which we have become acquainted at various times. Some of these qualities, since they are more constant, interesting, or practically important, we regard as essential constituents of the thing. In a general way, such are the tangible shape, size, mass, etc. Other properties, being more fluctuating, we regard as more or less accidental or inessential. We call the former qualities the reality, the latter its appearances. Thus, I hear a sound, and say a ‘horse-car’; but the sound is not the horse-car, it is one of the horse-car’s least important manifestations. The real horse-car is a feelable, or at most a feelable and *visible*, thing which, in my imagination, the sound calls up. So when I get, as now, a brown eye-picture with lines not parallel, and with angles unlike, and call it my big solid rectangular walnut library-table, that picture is not the table. It is not even like the table as the table is for vision, when rightly seen. It is a distorted perspective view of three sides of what I mentally *perceive* (more or less) in its totality and undistorted shape. The back of the table, its square corners, its size, its heaviness, are features of which I am conscious when I look, almost as I am conscious of its name. The suggestion of the name is of course due to mere custom. But no less that of the back, the size, weight, squareness, etc.

“Another well-known change is when we look at a landscape with our head upside down. Perception is to a certain extent baffled by this manœuvre; gradations of distance and other space-determinations are made uncertain; the repro-

ductive or associative processes, in short, decline; and, simultaneously with their diminution, the colors grow richer and more varied, and the contrasts of light and shade more marked. The same thing occurs when we turn a painting bottom upward. We lose much of its meaning, but, to compensate for the loss, we feel more freshly the value of the mere tints and shadings, and become aware of any lack of purely sensible harmony or balance which they may show. Just so, if we lie on the floor and look up at the mouth of a person talking behind us, his lower lip here takes the habitual place of the upper one upon our retina, and seems animated by the most extraordinary and unnatural mobility which now strikes us because (the associative processes being disturbed by the unaccustomed point of view) we get it as a naked sensation and not as part of a familiar object perceived.

"There is a whole batch of illusions which come from optical sensation interpreted by us in accordance with our usual rule, although they are now produced by an unusual object. The *stereoscope* is an example. The eyes see a picture apiece, and the two pictures are a little disparate, the one seen by the right eye being a view of the object taken from a point slightly to the right of that from which the left eye's picture is taken. Pictures thrown on the two eyes by solid objects present this sort of disparity, so that we react on the sensation in our usual way, and perceive a solid. If the pictures be exchanged we perceive a hollow mould of the object, for a hollow mould would cast just such disparate pictures as these. Wheatstone's instrument, the *pseudoscope*, allows us to look at solid objects and see with each eye the other eye's picture. We then perceive the solid object hollow, *if it be an object which might probably be hollow*, but not otherwise. Thus the perceptive process is true to its law, which is *always to react on the sensation in a determinate and figured fashion if possible, and in as probable a fashion as the case admits*.

"Visual feeling of movement is produced by any image passing over the retina. Originally, however, this sensation is definitely referred neither to the object nor to the eyes. Such definite reference grows up later, and obeys certain simple laws. For one thing, we believe *objects* to move whenever we get the retinal movement-feeling, but think our *eyes* are still. This gives rise to an illusion when, after whirling on our heel, we stand still; for then objects appear to continue whirling in the same direction in which, a moment previous, our body actually whirled. The reason is that our *eyes* are animated, under these conditions, by an involuntary *nystagmus*, or oscillation in their orbits, which may easily be observed in anyone with vertigo after whirling. As these movements are unconscious, the retinal movement-feelings which they occasion are naturally referred to the objects seen. The whole phenomenon fades out after a few seconds, and it ceases if we voluntarily fix our eyes upon a given point.

"No sense gives such fluctuating impressions of the same object as sight does. With no sense are we so apt to treat the sensations immediately given as mere signs; with none is the invocation from memory of a thing, and the consequent perception of the latter, so immediate. The 'thing' which we perceive always resembles the object of some absent sensation, usually another optical figure which in our mind has come to be a standard bit of reality; and it is this incessant reduction of our immediately given optical objects to more standard and 'real' forms which has led some authors into the mistake of thinking that our optical sensations are originally and natively of no particular form at all."

EPILOGUE. Now, judging from the tenor of those articles which adversely criticise *Dynamic Skiametry*, it seems plain that their authors do not grasp the fact that the addition of *plus spheric* lenses causes *accommodation* to be *relaxed* in-

stead of *taxed*, and that a *myopic* eye under convergence shows more *myopia* than it does under relaxation, or while trying to see at a distance.

An *emmetropic* eye, with an abundance of *amplitude*, in looking at an object 13 inches away exerts 3. D. of *accommodation*. If a *minus* 1. D. S. lens is added, the *accommodation* called for is 4. D., but if a *plus* 1. D. S. lens is added, in place of the *minus* 1. D., the eye will *not* relax to 2. D., and this is because of the *correlation of convergence*. If marked *esophoria* is present this may not hold true, but whatever *relaxation* does take place it will be *the required refractive assistance necessary to harmonize accommodation with convergence at this distance*, which, after all, is the *data* in the case that the optometrist is looking for. Then if the case will not finally accept any *hyperopic* correction for infinity it shows that a disturbed relationship between *accommodation* and *convergence* is present and that *heterophoria* or *sub-normal ciliary duction* may be factors.

In a *myopia* of 1. D. *convergence* is not exerted while the eye is trying to look at *infinity*, but when *fixation* is at 40 inches *convergence* is then exerted 3 degrees, and *this exertion unquestionably influences accommodation*.

Once more let it be stated that *dynamic skiametry is not the whole of optometry*, but that it gives an examiner valuable data that can not be obtained by any other known method.

Optometry covers the measurement of the *strength* and *tendencies* of the *extrinsic* muscles as well as the *strength* and *tendencies* of the *intrinsic* ones, all of which must be taken into consideration. Testing *amplitude of accommodation* and *amplitude of convergence* is very different from determining the *refractive assistance* an eye will readily accept for different points of fixation.

"Rules of thumb" are not always to be relied upon in optometry, for ocular conditions must be proven by various

measurements, and then, after all possible data is obtained, trained judgment is called for, as an eye may show a different measurement for a six-meter distance than it does for a one-meter one, or for a third of a meter, and there is a reason for this variation if an examiner is well enough informed to ascertain it. *Dynamic skiametry* is merely *one* method that is given to aid in the solution of the all-important question: *What lenses should be prescribed?*

Why other methods than *subjective* ones are needed in successful optometry may be readily inferred from the quotations on *mental perceptions*, here given, for in practical optometry all experienced examiners know the great variety of answers a given question, such as "which line is the blackest?" will call forth from different patients. Independent information that will serve to "*check up*" a patient's carelessness, stupidity or misinterpretation of a question is, therefore, no longer optional in *optometry*, but, on the contrary, *very vital* to its *theory* and *practice* and to its forward movement as a *profession*, to which, it is hoped, *dynamic skiametry* materially contributes.

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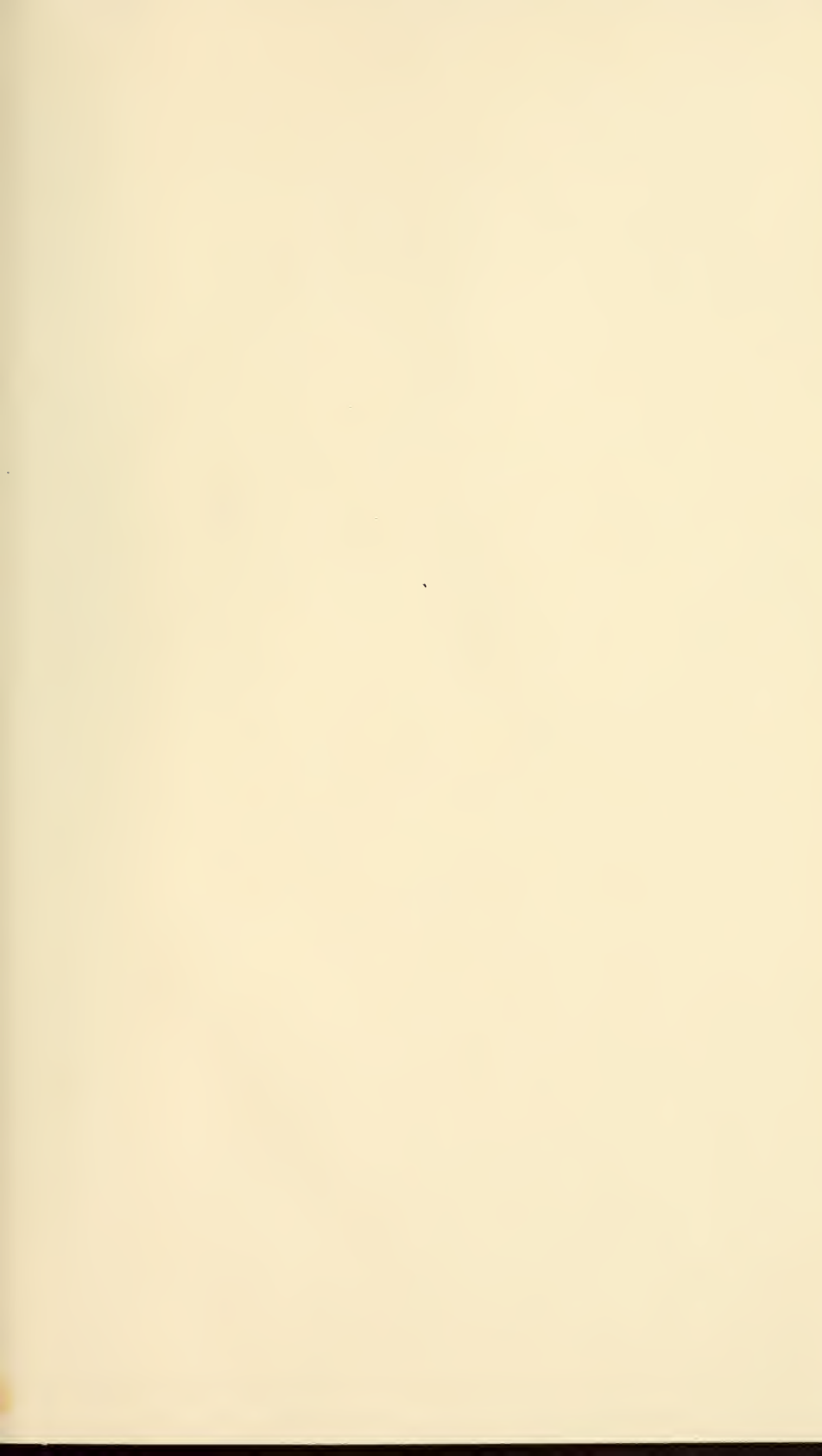
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